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THE FINANCIAL MEASURES NEEDFUL TO INDUSTRIAL STABILITY.

By James H. Eckels.

ONE of the hopeful signs of the times, and one which, indeed, is, in a measure, a direct legacy of good from an era which has often seemed almost wholly bad, is the awakening interest of the industrial world in the great questions of financial policy, and the growing demand that financial and tariff legislation shall be settled upon principles of sound wisdom and national stability.

The rapid increase in wealth, and the absorption of our people as a class in the exacting pursuits of trade, commerce, or industry, have left the conduct of the government so largely to the politician, and dissociated it so widely from the life of the ordinary citizen, that we almost forget that ours is a government not only of the people, but by and for the people. But business and professional men are awakening to a realization that this dissociation is no longer possible. They cannot remain absorbed in the erection of the great structures of successful enterprise, while the law-maker is shaking the very foundations beneath by swaying the finance and credit of the nation at the impulse of party platforms or private pressure.

And no one is more vitally interested in the maintenance of financial stability than the engineer, for the capital whose employment and direction is his life-work will not venture forth when the national credit is insecure and the national policy uncertain.

It was the appreciation of this that led THE ENGINEERING MAGAZINE to press these national questions to the front throughout the recent period of agitation. The *Railroad Gazette* throws its influence for sound money, because the railroads realize that a free-silver policy

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would mean universal bankruptcy. The *Engineering News* finds space for financial discussions, while a mining review debates the money question, and an electrical journal proposes free banking instead of free silver.

The best evidence that the whole financial system of the country is radically wrong is to be found in the fact that it is continually a subject of discussion and debate. All the depression in business circles which has been witnessed within the past few years is not to be charged to its defects, nor will the remedying of them insure the people against many losses in the future. There is no legislation which can be devised and put into operation which will prevent disastrous results following a disregard of the requisite rules of business sagacity. It is impossible that there shall be general accumulation where there is general extravagance, and bankruptcy is inevitable where, for a long series of years, there has been a steady expenditure beyond the income received. Over-trading, undue extension of credit, and unwarranted speculation can end only in ruin more or less widespread.

A general survey of the course pursued by the American people throughout the past ten years will show how very much causes, for which they alone are responsible, have contributed to produce the conditions of which they complain. No one, at the beginning of the liquidation of 1893, realized how prolonged would be the course it would run, or how extensive would be its sweep. It seemed not to have been known how very much capital and credit had been embarked in wild enterprises, having as a basis unwarranted expectation of profits. With each succeeding year since that time the public have become more intimately acquainted with the extent to which "booms" in cities and villages were developed during a period of flush times. If, at the time, it was not suspected that the undertaking being fostered was at all out of the range of the legitimate, or its capitalization in excess of an amount upon which a certain profit could be returned to the investor, that fact has since been made apparent. The surprising thing about it all, now that it is approaching an end, is not that so much wreckage has resulted, but so little. The total of the loss to individuals and corporations is only partially known to the public. Its knowledge is confined to the court records of assignments. It is wholly unacquainted with the shrinkage in values where complete bankruptcy has been averted, losses charged off without producing failure, and the assessments paid in order to repair capital and continue in business.

At the end of such a period, when the hope is general that improved conditions are to come and liquidation cease, the time is opportune

for such action as will certainly lessen the liability of a return of the experience through which we have passed. Added to the things enumerated as contributing causes of loss to the people must be the unwholesome effects of our monetary laws. Within the life of the administration just closing, one of the worst of monetary acts was taken from the statute-book. Others, however, remain, and, until a complete change is wrought in them, the country can never be entirely free from recurring danger. It is no part of the duty of the country's law-makers to enact or maintain legislation which makes the general government a partner in every citizen's private business undertaking, whether that legislation operates through a tariff system or through a financial one. In either case, to the extent that such legislation is put in operation, are introduced uncertainty, doubt, and, ultimately, danger, if not disaster. The source of much of the speculation of recent years developing panic and bankruptcy is directly traceable to legislation which created an artificial prosperity for a brief period. The general good of the country demands that the people be free in the future from law-made periods of prosperity ending in disaster, and that patent defects in existing enactments be remedied.

The result of the recent election was an emphatic declaration that our citizens want the best monetary legislation. As between the silver standard, carrying with it a debased currency, and the gold standard, expressing itself in a money of unchanging value, they have declared for the latter. The effect of doubt upon the subject as to just what was the view of the majority of the voters long worked harm to every business interest of the country, and added to the difficulties of the government. The government has persisted in following a policy of direct note issues by the treasury which more than once prior to 1893 had been a source of embarrassment to it and of weakness to the commercial world. That the danger from such issues was scarcely noticeable for some years after the resumption of specie payment in 1879 was only because time was necessary to develop the evils of other legislation affecting our monetary conditions. It took time to prove how burdensome was the enactment providing for the current redemption and the compulsory reissue of the legal tenders. The accruing loss through the coinage of silver under the provisions of the Bland-Allison act did not manifest itself until many silver dollars had been sent from the mint. Though the disastrous consequences of the Sherman law were known to the financial world from the first, the general public did not note such fact until two years had elapsed. Each of these ill-advised legislative financial palliatives weakened the resources of the government, injured its credit, and deranged the country's trade and commercial relations. The joint effect of all was to call attention to the

large amount of credit currency the government was attempting to carry, and the limited resources possessed by it to meet its full responsibility.

By statute it is declared to be the established policy of the government of the United States to maintain at a parity the various forms of money in circulation. Its ability to do so was strengthened by the repeal of the Bland-Allison act and the Sherman law. The full measure of relief will not be reached, however, until other steps are taken. These other steps are to provide for the redemption in gold of the legal-tender demand obligations of the treasury, to cancel them, and thereafter to refrain from entering into competition with the banks in the field of bank note issuing. Recent events have proven how extremely expensive the maintenance of these treasury notes is when doubt as to the ability of the treasury to redeem them in gold is even hinted at. The argument cannot be successfully advanced that it is unnecessary, now that the treasury is not being pressed for their redemption, to make them a subject of legislation. It has been already demonstrated that they are a cancerous growth, full of danger. The wisdom of the situation is to take effective measures for complete relief, through means known to be curative, instead of trusting to chance or time. If, again, the country is thrown into the distresses of panic and business disturbance, a quicker and larger resort will be had to these treasury issues in order to obtain gold for hoarding purposes, for all now understand the use of them. At one time, it may truthfully be said, many considered the government's treasury issues as one of its assets, instead of a liability. That day has gone, and everyone now realizes that not only are they not a source of wealth, but are, instead, a source of expense, loss, and uncertainty.

Provision for the payment of these obligations would be justified on the grounds that a danger to business undertakings would be thus removed, a continuing and increasing expense brought to a definite close, and the largest cause of a periodical want of confidence in the solvency of the treasury done away with. The failure to deal with them cannot be justified on any grounds. Legislation looking to this end must be had if the treasury department is to be rid of a difficulty more troublesome than a mere deficit in the revenues. It must either precede, or be embodied in, any banking legislation undertaken. If not made a distinct measure, it must find solution through a banking and currency act. Once rid of this trouble, some banking code could be enacted which would properly meet the demands of trade and commerce. The revision of the bank act, leaving the treasury still embarrassed and the secretary of the treasury powerless to meet the duties imposed upon him, would simply mean remedying an inconvenience and

stopping a small loss, while doing nothing to cure a deep-seated disease entailing the possibilities of complete destruction. Ultimately banks, guarded by safe restrictions, will be able, through issuing against bankable assets bank notes redeemable in gold on demand, to adequately supply the country with a currency sufficient for all purposes. They ought to supply all the credit currency issued, and they ought to be required to redeem it all in gold, thus shifting the responsibility for gold payments from the government to the banks, where it properly belongs. They should be given power to establish branches, and thus supply places now deprived of banking facilities with loanable capital and the means of obtaining credit. It is the province of banking institutions to meet the needs of the business world, and, in the doing of the things essential to the purpose for which they were created, they ought not to be unnecessarily hampered by the government or brought into competition with the government. Under existing laws banks today have their note-issues in direct competition with those of the government, while their deposits are lessened, and the amount of currency needed in daily business is curtailed, by the sub-treasury system. Whatever may have been the reasons for the excessive tax upon note-issues, and for the limitations placed upon their volume and the manner of issue, at the establishing of the system, they do not now exist. So, too, with the sub-treasury system. It is wrong in theory and hurtful in practice. It does not make the funds of the government more secure to it than other means of handling them would, and it does work, at times, great loss and hardship to the business world, because it needlessly withdraws large sums of money from the channels of trade to lie idle in the sub-treasury vaults.

In general, it may be said that the financial interests of the people will best be subserved by legislation providing for the payment in gold and cancellation of the treasury issues now outstanding whenever in the future they may be presented for redemption; giving to the secretary of the treasury adequate and unquestioned powers to protect the credit of the government at any and all times; granting to the banks enlarged powers of note-issue upon lines of public safety under proper supervision, designed to meet the commercial necessities of all sections, making them solely responsible for the redemption of the same in gold; and so modifying the sub-treasury system as to make it a public benefit instead of a business hindrance.

It may be argued that all this tends to place too much power in the banks. These questions cannot be properly determined, if they are to find solution only through alleged prejudice against institutions equipped with all the machinery necessary to meet the daily demands of business. Elsewhere banks, instead of treasury departments, issue

and redeem all the promissory notes which circulate as currency. Why not here? Elsewhere banks finance the affairs of the governments with which they have to do, without loss to such governments and without prejudicing the rights or jeopardizing the liberties of the people. Why not here? It is hardly to the credit of the people of this country that they insist on dealing with business questions from every standpoint save a business one. If other people, boasting less publicly of advance in the commercial world and of enlightened views on matters of public moment, can deal with banks as institutions productive of general good and as an aid to individual prosperity, Americans ought not to fall behind. When the people fully realize that the prosperity of the banks of the country but reflects the prosperity of the communities where they are located, less will be heard upon the platform, on the stump, and in legislative halls of their general destructiveness of the public welfare. As long as needed legislation affecting them and affecting the government's financial affairs is to be denied through, or molded by, party political necessities, exaggerated prejudices, and subservient cowardice, trade and commerce must suffer, labor be denied employment, and prosperity languish.

It is essential, therefore, that engineers, business managers, and men of affairs generally should realize the influence which may be wielded by personal letters to the members of congress, bringing the legislative bodies into fuller appreciation of the vital interests of industry and trade. Everyone whose life-work and direct contact with these questions enables him to see clearly the situation and its needs, should make it a duty to address his representative individually.

The effect of such communications, evidently born of accurate knowledge and profound conviction, will be of inestimable benefit, and will produce a public sentiment which no legislator will wish to set at defiance.

MISTAKES AND IMPROVEMENTS IN RAILROAD CONSTRUCTION.

By George H. Paine.

WHEN we trace the development of railways from their inception, one thing strikes us forcibly and immediately; carriages and locomotives made up to about the year 1840, no matter where, looked much alike, but those of later date, under the influence of certain tendencies, were more and more differentiated, until in 1850 the individuality of the rolling-stock of different lands became pronounced.

At present the American railway coach and its British relative no more appear to be designed for the same purpose than do a toy terrier and a St. Bernard seem to belong to the species *canis familiaris*. The differences consist not only in dimensions and internal arrangements, but in external finish and appearance.

Why this should have been so, what it signifies, where it has led us, and whither it is leading us will be the theme of this paper.

In making comparisons, English railway practice is used to set off American, since, although we belong to the same mixed race, there are fundamental differences of character that have caused us to adopt different methods in almost all matters of procedure. So truly have we followed our national tendency that to-day there is less resemblance between English and American railway track and equipment than between those of America and Germany. In England we find much resemblance between the early and recent types of cars and locomotives; the track also, in a large measure, has followed the same general conservative tendency, increasing in strength and dimensions as the demands due to higher speeds and heavier motive power required, but preserving in a remarkable manner the original ideas. In the United States the national characteristics have shown active influence both in line and equipment. The locomotives and cars are in every way different from the original types, except that they are propelled by steam and run on wheels, while the track itself has now little resemblance to early forms.

The conservatism with which the older countries, particularly England, entered upon the construction of railways stands in violent contrast with the enthusiasm displayed in the United States, where lines were built up hill and down dale; if a straight line was convenient, it was used; if not, we put in a curve; and, if an easy curve was inconvenient, we put in a sharp one.

Our national habit of "hitching our wagon to a star" and then "letting her go" was well exemplified in this matter. In Great Britain the mere granting of a charter was preceded by solemn and impressive rites. Parliament discussed it, committees sat upon it, witnesses were summoned, sworn, and questioned even to the butcher (literally) and probably to the baker and candlestick-maker. Engineers and others were examined as to the dangers attending the use of inclined planes (grades), and it was seriously and widely stated that a grade with an inclination of 1 per cent. (53 feet per mile) or a curve with a radius of three fourths of a mile (about a 1½-degree curve) were respectively as steep and as sharp as was consistent even with moderate safety when the terrific speed of their main-line trains was contemplated; sometimes, it must be remembered, they ran at an average rate of twenty-three miles an hour.

An excerpt from the abstract of evidence given before parliamentary committees in 1832 in the matter of an application to build a railway between London and Birmingham shows better than anything else the solid and rational method adopted by the authorities to ascertain whether or not the road was really needed for the public benefit, and, if so, to make it sure that the proposed line was the best for the purpose.

In the first place, the civil engineers testified to the cost, character, and physical peculiarities of the route. Here are a few of the details as given by Robert Stephenson, great son of a great father.

Twenty-two turnpike bridges: fifty-five parish-road bridges; one hundred and twenty inferior-road (highways of little use) bridges, and (think of it, oh, ye railroad builders of the year 1897!) two hundred private-road bridges,—in other words, farm crossings: all of this in the year 1832. The steepest grade was fifteen feet per mile; the sharpest curve appears to have had a radius of 4,000 feet; the ballast was of broken red sandstone, gravel, or chalk (on another line of the same period the ballast was laid twenty-one inches thick); the slopes varied from ¾ to 1 in chalk to 2 to 1 in clay and loose earth.

After the engineers had testified, landowners, farmers, hostlers, merchants, carriers, clerks in the stamp office, butchers, ship brokers, manufacturers, grocers, and, in fact, representatives of nearly every trade and industry, were called in to give evidence as to the necessity of the proposed line. Then, when the whole question had been canvassed; when the engineers had been made to prove that theirs was not only the most feasible, but a safe, line; when the directors had shown by their witnesses an actual business reason for its existence,—then and not until then was the construction authorized and the

public encouraged to invest. For not only did parliament think it best that no private rights should be violated in any form, but they also considered it their duty to see that no wild-cat schemes should operate so long as they could be prevented.

We have laughed and sneered at John Bull's dulness so much; it has so long been the fashion for his American cousins to think of him as an old fogy,—that it is now regarded by many as unpatriotic to say a word in appreciation of him; but let us see how we stand at the present time as compared to early English practice.

In at least one of the United States it is required by law that a certain proportion each year of the grade highway crossings on all railways be converted to either over-head or sub-grade crossings, while on many railways outside that State every effort is being made in the same direction through the initiative of the railways themselves. What has been saved to the English railways by this hard and fast rule in a total avoidance of claims for damages incurred at highway grade crossings and in lessening the necessity of watchmen, it is impossible to say; but it must be an immense sum, and quite equaled by the benefits which the public themselves have received. Some notion of the moral aspects may be gathered from the reports of the interstate commerce commission, the last of which says that in 1895 five hundred and eight persons were killed and nine hundred and sixty-one persons more or less injured at highway crossings by railway trains. Of this number not one was employed by the railway company, and all therefore, were, to that extent, innocent and unnecessary victims.

In another particular a great change has come over our practice within the past few years; this is in the matter of crossings between railway lines at grade. Whereas, in England, it was forbidden from the very start, (whether between the tracks of separate companies or between two intersecting tracks of the same company) we in this country seem not even to have considered the question, let alone tried to prevent the error.

At present, we find that, in some comparatively rare and noble instances, the railways themselves oppose the practice on principle and are willing to undergo a considerable and voluntary expense to prevent so criminal an arrangement; but, in the vast majority of cases, the dangerous feature is ignored and the fight, which nearly always occurs, is over the question which shall pay the watchman.

The general public, who must in one form or another ultimately pay the piper, are totally indifferent since, except for a small minority, they do not know that such a thing as a grade crossing exists.

The danger, which must always be present in a greater or less

degree when railways cross each other at grade, has been partly met in some states by requiring that interlocked signals shall be installed at all new crossings which may hereafter be formed. In a few states there are also certain laws which provide for the interlocking of previously existing crossings, under conditions, however, which are so vague that very little advance has been made except through the efforts of the railways themselves.

That interlocking is an immense advantage, is well known now and widely appreciated but where grade crossings are concerned it is merely begging the question, since the crossings themselves are an anachronism.

Even in 1832 the relations that existed between grades and the cost of hauling trains were carefully analyzed, and calculations were made by English engineers tending to show the cumulative cost of transportation on grades, and how it is that a more expensive, but more level, line will be cheaper and more convenient in the course of time. In consequence of this old fogyism (?), we to-day see the English railways operated over the original road-bed as it was originally laid out. It is known, of course, and appreciated that the cost of transportation per ton per mile in Great Britain is much higher than in this country; but this excess is largely due to their short average haul and to some other causes,—notably their complete arrangements for signalling trains, a sacrifice in economy made to and demanded by the public in the interests of safety. But, even though these two items do not account for all of the increased expense, it is a plain and simple proposition that, by reason of the superior physical conditions surrounding British railways,—conditions established when they were first constructed and therefore at the proper time and with the least expense,—it is a much easier matter for them to reach their ultimate economy in operation than for railways as a class in this country. We have some splendid examples of location, but how often we find long lines through an easy country which must be largely rebuilt in order to compete on even terms with other more intelligently constructed roads!

It is not a sufficient answer to the foregoing to say that in this country the population was too sparse, the amount of money too small, and the rates of interest too high to warrant the construction of such lines as have been described. In some cases, railways built in an ignorant manner have been able to make a living, and eventually to save enough money to pay for their reconstruction; but this is not the rule, and isolated instances, when contrary to the general experience, do not constitute proof; while it seems moderately sure that the few roads which have been able to survive under these adverse conditions, would

have been better off always, had they been properly constructed in the beginning.

A great deal is said regarding the benefits to the country at large that have followed the construction of railroads; but these benefits have been secured, in most cases, by immense individual losses. In these sacrifices and the inability of the stockholders to stand any further financial strain, we find one reason for the present physical characteristics and apparent tendencies of our railroads.

We unfortunately have no great court of last resort in the form of a well-digested public opinion to turn to or depend upon in matters which affect the individual. Examinations into the cause of a "ten killed tail-ender" are usually left to the intelligent research of a rural coroner's jury, which ends by censuring the poor devil of a flagman who did not go back far enough.

The truth of the matter seems to be that when the legislatures first chartered the railways, and for many years afterward, nothing was expected or required of the railways in return, which was at all commensurate with the privileges they received. The right of eminent domain was an immense power and should have carried with it a responsibility to the people which is only now beginning to secure recognition.

That this recognition sometimes manifests itself in an ignorant and dangerous manner is not surprising, nor the fault of the railways so much as it is of the people themselves. Who shall say that a company asking for a charter must refuse to accept any concessions which are offered by the grantor? But, nevertheless, an agreement which is unfair is neither good law nor good sense, and a careful authoritative supervision over our railways from the start would have been better for them, and better for the public, than are the present blind and tentative efforts to recover a control which ought never to have been surrendered.

It is not denied that to speak of government control is as a stench in the nostrils of many good citizens and comes perilously near the phrase "government ownership."

But why start at a phrase? The installation of various state railway commissions, the continued existence of the interstate commerce commission, the frequent enlargements of their functions, prove that it is to a limited control we are tending.

The method of investigation followed by the authorities in the London and Birmingham matter, as outlined in the first part of this article, was slow but sure, and, by making haste slowly, they were saved from many costly mistakes. Have they had cause to regret their deliberation? It appears not.

Like the man who decides to economize, and starts by refusing to pay his debts, we have begun at the wrong end ; and so we must sweat it out. In fact, we have been sweating it out for the last five years, and a good deal of impure matter has been expelled.

If the general good of the country required that unprofitable lines should be built, better results would have been secured by making it a matter of general expense by means of a subsidy, as is being done in many countries to-day. The rights of the individual would have been conserved, thousands of lives and millions in property would have been saved, better lines would have been built and better maintained, while at the same time many lines that have proved useless, ruining innocent investors and weakening public confidence, would not have been built.

There are, of course, many sides to this question, but, whether the opinions of the writer, as just stated, are correct or not, speculation upon it is by no means idle, since the hindsight of to-day becomes the foresight of to-morrow. And, whatever the reason, one thing is certain: very few railroads so poorly designed and constructed as were most of our early examples will be built in this country in the future.

"Pay as you go, my boy, pay as you go," was the advice of an uncle to his nephew.

"But suppose I can't pay?" asked the nephew.

"Then don't go."

Had this plan been followed, we should certainly have had fewer railroads, but these few would have been better built, there would have been fewer receiverships, and the persons who took the risks of construction would have reaped the profits.

We are but harvesting the fruits of our sins. The foreign engineers in the days of the first railroads were encouraged to build a tunnel in order to avoid a grade ; we built grades, not only to avoid a tunnel, but even to avoid a moderate cutting. Our development has taken place, not in the proper direction, but in embarrassing and unprofitable lines. In order to meet the competition of one well-built railway, a large number of poorly-located roads were forced to use locomotives of increased hauling-capacity ; this involved a greater weight on drivers, heavier demands on the track, which never was equal to the work, and the reconstruction of bridges. The civil engineer's plans were always based on the idea of catching up to the motive-power department ; generally speaking, he has not yet caught up, for a stern chase is proverbially a long chase. Through all his work may be seen that devilish question: "Will it do?" instead of: "Is it the best?" And the worst of it is that, although he usually gets the blame, he is not often the sinner. What are the real reasons why our railway track is usually not

up to its work? It is not because the engineers do not know, since, except in details, the track and roadbed have not changed in form for more than fifty years; it must, then, be some external influence which restrains them from adopting what is known to them as the best plan.

It is a good rule to name no names, but in the present instance it is better to break the rule. The late John Newell found himself president of the Lake Shore & Michigan Southern Railway in 1883, and, with the foresight of real genius, began the conversion of his line from what was a very good one into the very best which could be conceived for that location. It does not detract from the brilliancy of the project, which was the first one of the kind begun on a large scale, to know that he was forced into it because the owners of the line would not permit the employment of heavy locomotives,—the only other method by which train-loads could be increased and expenses reduced at the same time; rather, one is possessed with a greater admiration for the courage which led a man, restrained in the simpler and more obvious path, still to find so splendid a way of accomplishing his object.

Be that as it may, by diverting the line, by filling up old cuts, by cutting down old fills, by eliminating highway crossings, and at the same time rebuilding bridges in a stronger manner, curves were taken out, the grades in an east-bound direction were reduced to a maximum of 16 feet to the mile (except for a single piece of 5 miles), and the whole road was brought up to a physical condition fitting it to stand any conceivable weight of motive power as soon as the board of directors should experience a change of heart. What this cost will probably never be publicly known, but certain it is that not one cent of it was charged to the capital account,—a rather remarkable fact in the annals of American railroads, where it is not an unheard of thing to borrow the money with which to pay interest; in truth, in one instance, bonds were once issued to cover the cost of re-ballasting.

By the construction of wild-cat lines, by the poor construction of needed lines, by the use of stock to secure franchises, and by a hundred other utterly unnecessary, useless, and immoral processes, the public has now been brought to regard the stock of a new company as practically valueless, and representing nothing but wind or water. The roads must, therefore, be built upon borrowed money, and then pay interest or be sold out. Except in rare instances, only the bonds have a real value, and the stockholder who has actually invested finds himself in the shambles.

This, although it seems an issue quite apart from the subject in hand, is entirely apposite. When a railway finds difficulty in meeting its fixed charges, the first thing to suffer is maintenance,—a good

deal in the motive power and equipment department, but most of all, and invariably first and last, in the maintenance-of-way department.

A line is constructed on which the distances are great and the traffic light; it is built in the cheapest possible way, without much regard to physical characteristics in the matter of grades and curves, the lightest materials are used, and it is heavily bonded even before it is finished. On such a road every conceivable means of operating cheaply must be adopted; of these means the most evident is to cut down the number of trains by increasing the number of cars per train, and the only way to do this is to use heavy locomotives. In consequence, the track, always too light, and insufficiently ballasted, deteriorates rapidly, and requires renewals, which it seldom gets, since the demand for saving, as already pointed out, affects the maintenance-of-way department most virulently.

This frequently-repeated process has resulted in a type of track much different from that usually found in the older countries of the world; it is remarkably well suited to our conditions, and is not in any sense to be despised; still, it is not certain that it is the best, or that we should have had it under any other circumstances, while its evolution has been a decidedly expensive process.

It is evident now that there is really an awakening with us, not to the desirability of correcting those early mistakes in construction which the greater conservatism of the older countries enabled them to avoid, —for the desirability has long been admitted,—but to the immediate necessity for the work, which cannot be much longer delayed. The enlightened gentleman who is president of one of our largest railway companies recently called attention to the completion of one of these changes, and remarked that he should be satisfied with that as his monument; and well he may be, for few railroad companies ever attempted to operate over a more abortive location.

Current ideas, happily, are often, if not generally, diametrically opposed to those which were held a generation, nay, a decade, ago; and, although it cannot yet be claimed that the most recent developments are to prevail, yet it is safe to prophesy now that enough experience has been analyzed and recorded to hold us secure against most of the mistakes of the past.

This statement is to be qualified also by the recognized possibility that some radical change in the form of vehicle or force of propulsion may take place, which will modify the demands made upon the superstructure of the line, and thus require a change in its form.

It has been shown how the difference in form between the American and British rolling stock has been accompanied by nearly as great differences in the form of the track; but, since we are chiefly

dealing with the things which are, speculation as to the possible changes in the prevailing force of propulsion need not occupy us.

Within all human probability the limit of weight per wheel has been pretty nearly reached, and nothing threatens the existing well-built track but increased speed. This is certainly coming, both with freight trains and with passenger trains, but it will come gradually, and is a much easier condition to meet than was that of increasing weight. With improved rail joints and drainage, most of the requirements are already fulfilled, because, on a perfectly smooth and rigid surface, there is no shock at any speed. Of all the inductive lessons which have been taught to maintenance-of-way engineers, this is the most important and valuable. Reasoning from a false premise, elasticity was long considered an absolutely necessary quality in track, and the belief extended even to the ballast. That there can be no such thing as true elasticity in such materials as railroad ballast is composed of should be evident enough, and that the contrary was believed, although but for a short time, is to be accounted for only through (according to Hamerton) the vast ability of the human mind to resist knowledge. It is easier to understand why the rail and ties were believed to require a display of elasticity, since it has been shown that the track has been almost always over-strained; in fact, to avoid any misunderstanding, it may be admitted that they should be very elastic; but that they should be asked to perform work which would demonstrate it—that is, be made to deflect and spring back like a piece of hickory—was a wrong idea, now pretty well exploded. Since it was born of conditions which are rapidly disappearing, it is instructive only in teaching what to avoid.

The old argument was: "Our track deflects greatly under a train; so make it as elastic as possible, in order that it may recover its normal position, and not take a permanent set."

The present reasoning is: "If our track deflects greatly under a train, it is too light, and must, therefore, be strengthened, in order that it shall not be required to display its elastic quality."

It may be regarded as a law that, the less motion there is in a railroad track as a whole, or between the adjoining parts of a railroad track, the better it will fulfill its function, the less damage it will sustain from a train, and the less the train will suffer in passing over it.

It is in this direction that the improvement in the details of track is to be expected, and these particulars will be treated in a subsequent article. In general, we shall see more regard paid to economical location, from an operating rather than from a construction standpoint, and a greater permanence will be aimed at to reduce the cost of maintenance.

THE POSITIVE VALUE OF QUIET AND BEAUTIFUL STREETS.

By J. W. Howard.

MANY and diverse motives cause men to undertake a great variety of tasks. Whatever they seek, be it pleasure, profit, or the necessities of life, they are compelled, directly and indirectly, to use city streets. The supplies which are needed for the existence of thousands of people in each city pass through some portion of the streets; either under them, in conduits or pipes, as water and gas; or upon them, in vehicles or carried by hand; or above them, through electric wires conveying light or bearing information by telegraph or telephone. The products of our labor pass to their destination through many channels of transportation, but almost always a portion of the way over the pavements of streets.

Modern conditions have changed the problem so completely that the old solutions are no longer adequate. To carry conviction of this fact, pictures often appeal to a reader better than too much text. With this in mind, the illustrations of this article have been chosen; not with a view to showing the most beautiful streets of the world, but to exhibit certain facts carefully explained under each picture. Many articles have been published concerning good roads and pavements, but too few pictures have appeared. They speak louder than words.

City streets, with their pavements and other equipments, affect each man, woman, and child. The air and daylight come to the dwellers in cities principally by means of the spaces provided by the streets. We rely upon the streets for so many necessities, comforts, and conveniences that to properly construct, equip, pave, and maintain a city street requires a careful consideration of many other needs than those of horses and vehicles. Comparatively few persons own or use horses. Electric and other powers have so reduced the number of horses that the horse is to be considered less than heretofore in our street-paving problems.

Consider for a moment a few of the many questions involved in modern street-construction. Each of the following matters must be provided for, and their relative importance and position kept in mind, by our city engineers and others who attempt to administer our thoroughfares.

They must provide for air; natural light by day and other light by night; surface drainage; sewers; pavements of roadways and

NEW YORK CITY. BROADWAY.

Streets are used by all and should interest all. Pavements are not for vehicles only. Many other interests are involved.

sidewalks ; water pipes ; hydrants ; posts and poles for various purposes ; wires and their arrangement, above ground when necessary, and under ground when possible ; and boxes for post-office, police, fire-alarm, and other purposes. We have need of places of public comfort, so necessary to the health and convenience of the dwellers in dense populations and so lacking in too many American cities.

Benches are welcome, and add much to certain streets with broad sidewalks. They can be placed, as in a few American and many

European cities, at selected points near the edge of the sidewalk, and sometimes elsewhere. Drinking-fountains for man and beast should appear at reasonable intervals. Many people really suffer from thirst, when on the streets of American cities. All men are not willing to enter saloons, and, if water is desired, instead of beer, soda water, or other artificial beverages, even men who do not object to saloons do not wish to ask for water there. Many men are too poor to purchase that wherewith to quench thirst. Women and children of the middle and poor classes are the greatest sufferers in hot weather because of the lack of drinking-water easily accessible to the public. Fountains, moreover, make a city homelike, and can be made after handsome patterns, thus beautifying the streets.

Special stands for affixing posters and other advertisements are in use in Paris, Berlin, Frankfort, and elsewhere. They prevent advertising from becoming an eyesore. These stands are large enough to contain a person, who may use the lower portion for the sale of printed matter, newspapers, flowers, etc.

PARIS STREET, 1740, WITHOUT PAVEMENT.
Impeding travel, causing discomfort and disease.

Grass-plots, parking, and even fountains and statuary have their proper places on the surface of many streets. Trees are useful, healthful, and handsome, and should be more used in the majority of American cities, even on a few business or semi-business streets. A visit to Washington, Buffalo, and a few other cities having trees, will convince one of the benefit and beauty of city trees. If no signs, advertisements, or wires are attached to them, trees in a street render it very attractive.

Tie-posts for horses and stepping-blocks for carriages have become

SEVILLE, SPAIN. 18TH CENTURY PAVEMENT.

System still used in Spanish and South American cities. No sidewalk, central gutter.

a source of danger on many streets. When in a poor state of preservation, they are very unsightly. But, where the population is not dense or the thoroughfare crowded with travel, such tie-posts and stepping-blocks are perfectly admissible.

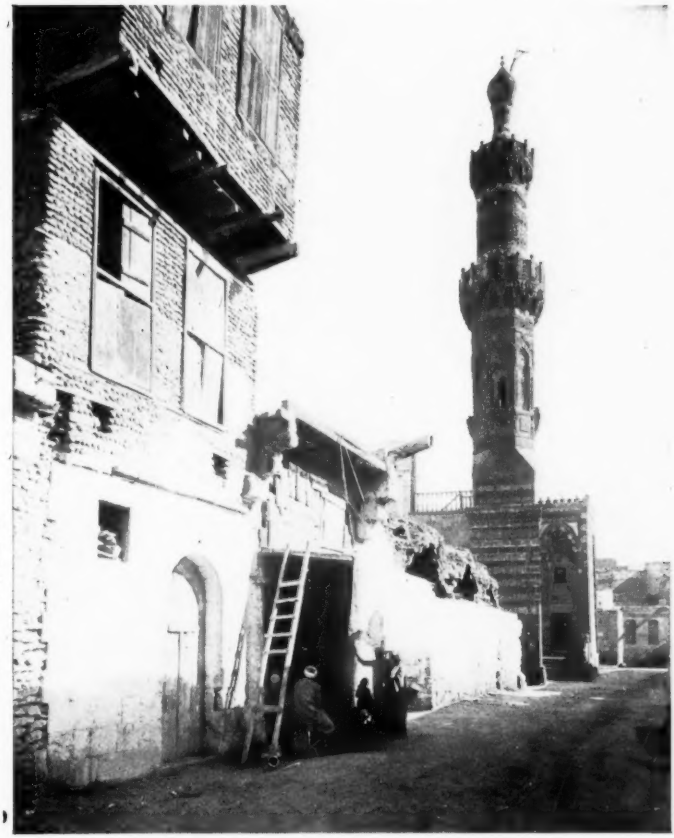
The subterranean arrangement of the conduits for water, gas, steam, compressed air, electricity, and other appliances is complex, and demands the combined experience of many men. All of these

SCUTARI, OPPOSITE CONSTANTINOPLE.

Street pavement of small Turkish cities, as poor as the civilization.

TANGIERS, MOROCCO. THE KASBAH.

Pavement characteristic of the main streets of the largest Mohammedan cities. Contagious diseases lodge in it.



CAIRO, EGYPT. STREET WITH NO PAVEMENT.
Such streets are used from necessity, not for pleasure.

things seriously affect the pavement, and especially its maintenance or repair. When access to such conduits becomes necessary, indiscriminate destruction of the pavement too often results. Full power to regulate this matter should be placed in the hands of a single official, who, in turn, must be responsible to the elective or appointive power above him for the proper fulfillment of his duties and the maintenance of the pavements.

Street cars, their tracks and their needs, add difficulty to the prob-

lem, especially to the laying, maintaining, and cleaning of the pavements. Rails, switches, and flanges which project above the pavement prove very objectionable. They cause unequal wear and ruts in street surfaces, the proper repair of which absorbs thousands of dollars in each city. Generally the repairs are not made. Then the obstruction to traffic and street-cleaning causes great expense to the private and public purse. Thirty per cent. of the cost of proper repairs to pavements on streets having center-bearing, side-bearing, or other poor rails, is caused by the presence of these rails. Traffic seeks, or

GOETTINGEN, GERMANY. 18TH CENTURY STREET OF NORTH EUROPEAN CITIES.
Rough, solid pavement, with gutters at the sides.

is compelled to follow, the rails. Ruts form, and irregular wear is unavoidable. Thirty per cent. of the cost of sweeping (not removal or disposal) of the dirt from the streets of New York in 1896 was due to the poor forms of rails and the ruts they caused.

The form of steel rail which is most efficient and economical for all concerned is a firmly-set girder-rail with a flat upper surface containing a groove. The slight cost to the street-car companies of cleaning the groove at intervals is less than the cost arising from the delays due to vehicles obstructing the rapid passage of their cars.

PARIS, RIVOLI STREET AT ENTRANCE TO LOUVRE PALACE.

Grooved street-car rails prevent a street from wearing in ruts, even under extremely heavy traffic.

DUBLIN, IRELAND. SACKVILLE STREET.

A rough pavement and badly arranged tracks destroy the beauty of an otherwise handsome street.

Grooved rails save the companies the large expense (which they should justly pay) of repairing the injury to pavements traceable directly to the presence of rails of projecting forms.

No private or other enterprise upon city streets is warranted in imposing avoidable expense upon the public, or, where pavements are laid under guarantee or maintenance contracts, in imposing upon contractors the cost of excessive repairs to pavements. In equity, as well as to provide even street surfaces, city after city is following the example lately set in New York, long since established in Washington, and for many years in vogue in Europe, of permitting only flat-surfaced and grooved rails to be used on the streets.

THE PIAZZETTA, VENICE.

The pavements of many Italian cities are laid as a part of the city architecture, for beauty and utility.

The construction of pavements and roads requires as close observation, study, and supervision as other technical work. France set the example in this connection, when it established during the last century its engineering school of bridges and roads. Men were trained, scientific methods were employed, and experience was recorded for the benefit of the existing and each succeeding generation. Other nations in their engineering schools have long been doing the same.

Almost every one can think of a city, or part of a city, with disagreeable streets, either without pavements or surfaced with poor pave-

FLORENCE, ITALY. LOGGIA DEI LANZI.

Attractive streets retain successful citizens, draw strangers, and are a source of pleasure and profit to a city.

ments which absorb, breed, and disseminate germs of disease; pavements which cannot be thoroughly cleaned, obstruct traffic, cause useless noise, and are an injury to the health, comfort, and wealth of the community. Such pavements drive away successful men, and prevent new and energetic men from coming to the city and giving it the

benefit of their capital and energy. A city, to succeed, must properly pave its streets, keep them in repair, and clean them.

The utility, economy, and beauty of a pavement, fortunately, go hand in hand. The best pavements are those which are laid on solid foundations and have smooth or even surfaces. They either have no joints, or the joints are made impermeable to moisture. Such pavements are the best for wheel and foot traffic. They are the easiest to keep clean and in repair. All expenses considered, they are the most economical, and at all times handsome and attractive.

No single pavement is suited to all cities, or to all streets of one city. Asphalt, granite, brick, wood, macadam, and other materials

PARIS, AVENUE DE L'OPERA, CUT THROUGH A DENSE QUARTER.

The increased rental and tax values more than compensate for many houses removed. Business, health, and beauty are improved.

have their proper places. The problem is to decide upon the materials and methods for each street.

The construction of pavements, their maintenance or repair, and their relation to street-cleaning have lately been ably treated by others in this magazine. This article is an attempt to show the importance and difficulty, as well as the advantages and beauty, of well equipped and properly-paved streets.

Street engineers of true worth are as much needed as bridge, sanitary, hydraulic, landscape, and other engineers. All are sub-divisions

PARIS. AVENUE CHAMPS ELYSÉES.

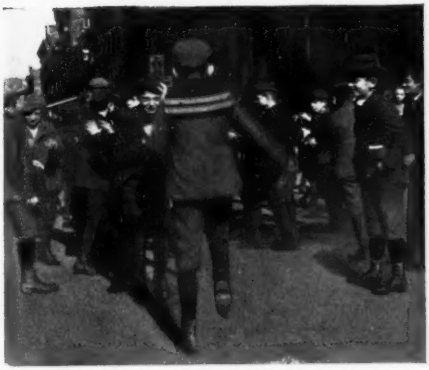
Central driveway, with parkways and roadways on each side. Such promenades enhance civic pride and contentment.

TURIN, ITALY. SMALL PARK AT RAILROAD STATION.

Many foreign, and a few American, cities thus make the place of arrival handsome and thereby impress strangers favorably.

PARIS. ESPLANADE BEFORE NOTRE DAME CATHEDRAL.
Laying asphalt pavement for vehicles, foot traffic, processions, and ceremonies.

BUFFALO. NORTH STREET.
A smooth, clean, quiet pavement, grass-plots, and good walks, make a satisfactory setting for homes.



NEW YORK CITY, CHRYSTIE STREET.

Children, especially in tenement districts, must play in the streets; hence the greater need of clean pavements.

of civil engineering. Such men are steadily replacing mere politicians and the ignorant or apathetic employees of cities or contractors. They accomplish maximum results with minimum expense. They unite theory and practice of the past and present. They have access to the recorded experience of others, and thus avoid useless experiments.

The results tells the story. Compare the new asphalt and granite pavements of New York with those of 1887. Examine the streets of Washington, Paris, London, Berlin, and a few other cities, and you will find the good results of honest administration, with trained men in charge of pavements. Every thinking man can name other cities, where the poor pavements indicate either that

PHILADELPHIA, SECOND STREET. A NEGLECTED PAVEMENT.

The public in some cities may be educated down to enduring such a cause of offense.

NEW YORK, NASSAU STREET.

Valuable buildings on a narrow street need a smooth, clean, and quiet pavement to make the lower offices valuable.

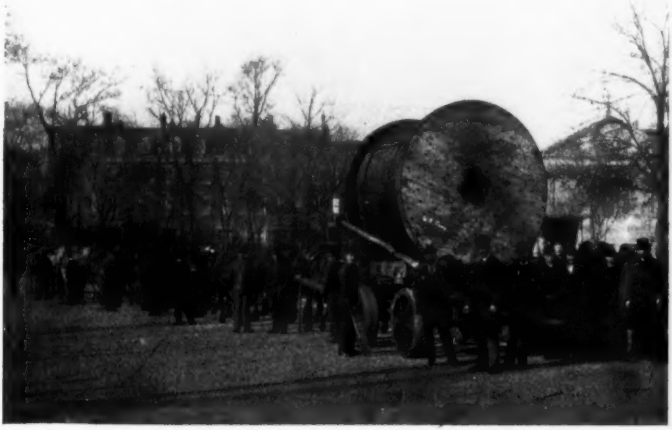
honesty is not present, or that trained, educated men are not in charge of street-construction.

Examples of attractive pavements and handsome streets are easily found in America, for great progress has been made here, although it is but a grand beginning. European cities are generally more complete, as a whole, but it is no longer necessary to cross the Atlantic to see what can be done in the matter of pavements.

The sale or rental value of real estate increases beyond the expense of the improvement when a good pavement has been laid, especially when noise has been guarded against by proper choice and laying of material. Noise was formerly regarded by many as a necessary evil in

NEW YORK, PARK AVENUE.

The central part of a wide roadway should often be parked and beautified.



NEW YORK, WASHINGTON SQUARE, SOUTH END OF 5TH AVENUE.

A handsome pavement on a solid foundation is not injured by the heaviest load.

WASHINGTON, D. C. CONNECTICUT AVENUE.

Flat grooved rails, firmly set, should have the asphalt pavement laid against them.

WASHINGTON, D. C. THOMAS CIRCLE.

One of many green spots with good pavements about them which are so agreeable in well-finished cities.

connection with durable pavements. The asphalt, wood, and brick are used with success in reducing noise. Some brick pavements, however, when laid in cold weather and with rigid base, often give forth a disagreeable, hollow, rumbling sound.

Another marked improvement is the elimination of cross-walks or bridge stones where they are useless and unsightly, because a street, if properly paved with asphalt, wood, or even granite, can be crossed on foot at any point.

The narrowing of paved roadways of residence-streets, away from the centers of cities, is advisable, especially when smooth pavements are used. This is because such a surface facilitates rapid traffic ; as the vehicles pass in less time, less width of roadway is needed. Not only is the expense of much extra pavement saved, but often space is obtained for grass plots between the sidewalk and curb of the street, as shown in the picture of North street, Buffalo.

It is natural and proper that people should take pride in a street well furnished with all that serves the needs of a high civilization. Such streets and their pavements benefit those living upon them. They cause an improvement in the appearance of the people—especially in tidiness of houses, dress, and even manners—in the poorer parts of cities.

The health of the people is improved, and the death rate diminished, where impermeable pavements are used. The dust and dirt which get into our houses come from the street. Disease germs are thus brought to us when a kind of pavement which absorbs or retains matter is used in a densely-populated city.

Good pavements and attractive streets have an ever-increasing army of friends. The general use of the bicycle has helped to spread knowledge of this subject, especially because the possessor of the propelling power (the legs) can feel the superiority of smooth roadways, and can talk. The horses have long suffered while drawing heavy loads over rough streets, but could not complain. If they could have talked, we would have learned, generations ago, what too few people were then willing to observe. When motor vehicles or horseless carriages shall be at last in practical daily use, a new army of advocates will be added to the common cause of good pavements.

COMPARATIVE ECONOMY IN ELECTRIC-RAILWAY OPERATION.

By Charles Henry Davis.

BUT little has been written upon the subject of coal consumption on electric railways; except in isolated cases, of specific plants undergoing test, no great collection has been made of data available for comparison, or which can be used to arrive at correct conclusions. The writer undertook to collect sufficient data to determine reliable averages of coal consumption per car-mile, and to show the comparatively small percentage of saving in operating expenses per car-mile in power stations of the greatest economy over those of minimum economy, compared to the large percentage which can be saved in other departments with the same expenditure of capital; or, in other words, the undesirability, in many cases, of expending large sums of money on concentrated, compound- or triple-expansion, condensing-engine plants to save a comparatively small percentage of the cost of operating per car-mile, when part or all of the same amount spent upon other items, which are a larger percentage of the total operating expenses, would result in greater savings.

In the October, 1896, number of THE ENGINEERING MAGAZINE, under the title, "The Economy of the Modern Engine Room; II. The Problem of Engine Selection," the writer gave the following as fair average steam consumption in pounds per h.-p. hour for railway work (balance of table omitted here):

		POUNDS OF STEAM.	
TYPE OF ENGINE.		NON-CONDENSING.	CONDENSING (C).
High-Speed	(H. S.)	36	31
High Speed Compound	(H. S. C.).....	27	22.5
Corliss	(C)	31.5	26.5
Corliss Compound	(C. C.)	26	23

This table shows a saving of 36 per cent. between the high-speed engine plant running non-condensing at 36 pounds of steam, and the Corliss compound-condensing at 23 pounds; Table No. 3 shows that the high-speed engine plant averages about 15 pounds of coal per car-mile, while the Corliss compound-condensing averages about 8 pounds, —a saving of 46 per cent., sufficiently close to the 36 per cent. given above to indicate that the coal tables give fairly accurate averages. By examining the coal tables we are led to the conclusion that the

efficiency of each system is approximately the same, for we find, in general, that, where the number of car-miles is high, the consumption of coal per car-mile is low; in the north central and western States, where coal is not of as good quality as in the eastern States, the consumption is higher (assuming, as we safely can, for our purpose, that the economy of various types of boilers is practically the same); with roads using hard coal there is an apparent higher average in consumption of coal, no doubt due to lower car-mileage and fewer cases; and in engine plants, as more economical apparatus is used, the coal consumption decreases. It would therefore seem that we are correct in assuming that the total efficiency of each system is approximately the same, though varying in each part that goes to make up the whole. The variation from 25.9 maximum to 5 pounds minimum shows the approximate value of this information, and the engineer is able to predict results only from careful tests and thorough knowledge of local conditions.

Omitting exceptional cases, both as to minimum and maximum, it is found that the cost of operating an electric railway under ordinary conditions is about 13 cents a car-mile, divided about as follows with coal at $3 per ton of 2,240 pounds: *

Power,	$ .015,	11.5%,
Cars,	.025,	19. %,
Track and line,	.035,	27. %,
Car labor,	.055,	42.5%,
	$ .13 cents.	

It is seen that power is eleven and one-half per cent. of the total operating expenses per car-mile; the coal item will average about 50 per cent. of the power-house expenses, or about 5.75 per cent. of the total expenses per car-mile. Fifteen pounds of coal per car-mile can safely be depended upon with high-speed engines running high pressure and single expansion, but this can be reduced to about eight pounds with the most economical steam plants. From these figures it appears that a maximum saving of 46 per cent. of the coal, or of 2.6 per cent. of the total cost per car-mile, could be made by the use of the most economical plants as compared with single expansion. We assume that, on an average, high-speed engine plants burn about 4 pounds of coal per horse-power per hour, equivalent to an evaporation of about 9 pounds of water per pound of coal. If 2.6 per cent. is the maximum saving which can be realized, the chances are that, under most circumstances, far less is likely to be accomplished. Most en-

* See "Facts and Figures Interesting to Electric Railroad Men," third edition, by the author.

gineers agree that, above 5,000 horse-power or even less, there is usually no material saving in further concentration of power, and compound-condensing plants do not show enough saving in small stations to more than balance the interest on the greater cost. To effect the above saving, bearing in mind the last two statements, would necessitate expending anywhere from 100 per cent. to 30 per cent. more in first cost, depending upon the size of the station. Suppose a part or all of this increase were spent on better car bodies, trucks and motor equipments, or on track and feeder lines (including returns), resulting in a saving not only in each of these departments, but in that largest of all items, car labor, by increasing the speed without danger to the public. A saving of 10 per cent. on cars, 7.4 per cent. on track and line, or 4.7 per cent. on car help, would amount in each case to a saving of 2.6 per cent. per car-mile, equivalent to a saving of 46 per cent. in the coal pile, and could probably be accomplished, in any given case, with a smaller expenditure of capital.

An example may more distinctly indicate the truth of this position. The following table has been prepared from data obtained from two electric railways designated as 1 and 2. The first shows lower cost of operating per car-mile, due to heavier and better track, line, and equipment, although the power plants are about equal in economy; note also the fact that the indicated horse power per car used is much lower in road 1 than in road 2.

A COMPARISON OF ECONOMY IN ELECTRIC-RAILWAY OPERATION.

	ROAD.	
	No. 1.	No. 2.
Street length, miles }	4.11	6.00
feet }	21,700	31,680
Track length, miles }	7.54	6.36
feet }	39,811	33,584
Steepest grade—per cent	5.2	6.0
Length of steepest grade—feet	475	500
Number of motor cars	12	7
Number of trailers	15	4
Average total cars used at once	9	4
Indicated h. p. of engines	425	300
Indicated h. p. per car used	47	75
Car miles operated	317,656	92,400
Operating expenses per car-mile—cents	9.77	13.68
Total operating expenses	$31,030.	$12,640.
Total cost of road and equipment	266,730.	115,694.
Approximate cost of buildings and real estate	30,000.	15,000.
" " " power plant	29,750.	30,000.
" " " equipment	58,500.	16,800.
" " " track and line	148,480.	53,894.

It will be seen that the cost of track and line in the first case is about $20,000 per mile, while in the second case it is about $8,500. Part of this difference is due to cost of paving in the first case, which aver-

aged about $5,000 per mile ; the rest is due to heavier rail, ballasting, substantial ties, heavy pole work and feeder lines, and proper bonding and returns, while the equipment was heavier and more powerful and substantial on road 1, thus giving lower operating expenses.

The writer does not want it understood that he is not in favor of concentrating, compounding, and condensing where conditions show an actual saving when taking into account the interest on the increased cost ; but he calls attention to the enormous amounts spent on 10,000 and 20,000 h.-p. plants, and even higher horse powers concentrated at one point, which do not produce a horse power any cheaper than smaller stations, and which cost more per horse power and force tremendous investments for feeder systems, and in their large cost cut down the amounts that managers of corporations allow (or have left) for the other and more important items. It should be remembered that these items offer a large field for saving, because of their greater percentage of the whole. It is interesting to note, as bearing on this subject and as additional indication of the correctness of our position, that a steam road, from which the writer has data, using over 200,000 tons of coal per annum and operating over 42,000,000 car-miles, consumes about eleven pounds of coal per car mile in its locomotives. Remembering that the weight moved, in this case, is considerably more than double per car (exclusive of other conditions), and that small detached steam plants are used, running high pressure and single expansion, this is a strong point against the prevailing methods of our large electric-railway systems. Should the rotary transformer be extensively used, the correct solution of any problem might be different, for the problem of current distribution is of an entirely different character.

The amount of coal consumed per car-mile is dependent upon so many conditions, often unknown, that this amount, in any given case, cannot be used to predict what the consumption will be on another road ; hence the importance of taking a large number of cases upon which to base our average results, which may then be considered fairly reliable for the determination of possible results in any new case. It will readily be seen that the amount of coal consumed per car-mile depends upon the tons moved, the height through which each ton is moved, the speed, and the efficiency of the entire system ; the first three are almost impossible to obtain on any large number of roads from the ordinary records kept, and can usually be secured only by specially-arranged tests ; the efficiency of the system depends upon that of each part, such as the boiler plant, engines, condensers and piping, generators, over-head line, ground return, track, and equipment. High economy in all but one part of the system might cause

TABLE No. 1.

Road.		State.	STEAM PLANT. Miles.	Boilers.	Engines.	Kind.	COAL. Coal field.	Tons used, 2240 lbs.	Lbs. used per car-mile.
NORTH ATLANTIC STATES (as per U. S. Census—1890).									
56	E	Maine	116,926	V. T.	V. C. C.	S	Virginia	508	9.7
42	E	Massachusetts	196,824	R. T.	C. C. C.	S	Georges Creek, Md.	939	10.7
65	E	"	16,794,961	"	" " "	S	" " "	52,878	7.0
189	E	"	917,956	W. T.	H. S. C. C.	S	Georges Creek, Md.	2,261	5.4
74	E	"	873,177	"	" "	S	" "	2,262	5.8
451	E	"	226,123	R. T.	C. C.	S	" "	594	5.0
308	E	Ohio	1,378,518	"	" "	S	Pennsylvania	3,189	5.2
802	E	Connecticut	146,000	V. T. R. T.	H. S. C.	S	"	1,000	15.3
398	E	New York	819,000	V. T.	V. C. C	S	Pittsburg	2,176	5.9
78	E	"	2,162,134	W. T.	H. S. C. C. C.	H	"	8,758	9.1
249	E	"	637,290	W. T.	C. C. C.	S	"	5,100	17.9
214	E	"	199,290	W. T.	H. S.	S	Reynoldsville, Pa.	1,460	16.4
281	E	"	350,000	W. T.	H. S. C.	S	Clearfield, Pa.	1,200	7.7
181	E	"	293,345	R. T.	V. C. C.	S	Reynoldsville, Pa.	682	7.2
80	E	"	7,164,258	W. T.	V. C. C.	S	"	23,597	7.4
724	E	"	137,970	V. T.	H. S.	H	"	1,060	23.7
609	E	"	4,358,136	"	" "	S	"	19,043	9.3
842	E	"	73,377	R. T.	H. S. C. C.	S	"	640	19.5
668	E	"	247,482	"	" "	S	"	1,130	10.2
90	E	New Jersey	87,923	R. T.	H. S.	S	Clearfield, Pa.	387	9.8
558	E	Pennsylvania	149,730	R. T.	H. S.	S	"	1,231	18.4
229	E	"	600,000	V. T.	V. C.	H	Hazleton, Pa.	3,600	13.4
211	E	"	514,649	R. T.	C. S.	H	Girardville, Pa.	2,852	12.4
54	E	"	400,248	W. T.	H. S. C.	S	Dawson, Pa.	1,697	9.4
580	E	"	901,400	W. T.	H. S.	H	Schuylkill Co., Pa.	2,250	10.0
103	E	"	833,000	R. T.	C. C.	H	Liken's Valley, Pa	3,000	8.1
SOUTH ATLANTIC STATES (as per U. S. Census—1890).									
811	E	D. of Columbia	534,000	V. T.	H. S.	S	Cumberland, Md.	1,800	7.5
809	E	"	365,000	R. T.	C.	S	" "	1,300	9.2
813	E	"	528,500	W. T.	H. S. C.	S	W. Virginia	2,030	8.6
128	E	Georgia	98,550	W. T.	H. S.	S	Alabama	638	14.5

the pounds of coal per car-mile to be high, and it is therefore impossible, without special test, to accurately determine the cause of low efficiency in any given case. By taking a large number of cases, and eliminating those which are evidently far from the average, we get approximate information indicative of what we may expect.

The information given in the tables was obtained by the writer during the winter of 1894-95. Over 600 roads were addressed, from nearly all of which replies were received; much of the information sent was evidently largely guess-work, not based upon carefully-kept records; many wrote that they had no information that would enable

TABLE No. 1 CONTINUED.

Road.		State.	Miles.	Boilers.	Engines.	Kind.	Coal field.	Tons used, 2240 lbs.	Lbs. used per car-mile.
NORTH CENTRAL STATES (as per U. S. Census—1890).									
648	E	Missouri	2,021,938	V. T.	C.	S	Illinois	16,670	18.5
150	E	Ohio	449,680	.....	C.	S	Jackson Co., Ohio	2,555	12.7
576	E	"	331,000	R. T.	H. S.	S	Wellston, Ohio	1,500	10 1
220	E	"	363,040	R. T.	C.	S	" "	2,300	14.2
222	E	Indiana	319,345	V. T.	C.	S	Illinois & Indiana	3,140	22.0
107	E	Illinois	1,514,892	W. T.	C. C.	S	... .	9,080	13.3
43	E	"	530,000	W. T.	H. S. C. / H. S. C. C.	S	Streator, Ill.	4,400	18 6
256	E	"	425,000	R. T.	C.	S	" "	3,500	18.4
250	E	Wisconsin	150,000	R. T.	H. S.	S	Duquoin, Ill.	1,500	22.4
594	E	"	515,000	W. T.	V. C. C / H. S. C. C. / C	S	Pittsburg, Pa.	2,190	9.5
170	E	Minnesota	1,133,188	W. T.	C. C. C.	S	....	5,510	10.9
148	E	Iowa	1,549,060	V. W. T.	H. S. C.	S	Violo, Ill.	11,400	16.5
257	E	Missouri	223,130	R. T.	H. S.	S	Pittsburg, Kan.	2,090	21.0
648	E	"	2,021,938	.....	....	S	....	16,670	18.5
825	E	"	395,650	R. T.	C.	S	Crawford Co., Kan.	2,150	12.2
743	E	"	378,995	R. T.	C.	S	Pittsburg, Kan.	1,980	11.7
53	E	Nebraska	100,000	R. T.	H. S.	S	Kansas	800	17.9
295	E	"	1,145,158	V. T. / R. T.	H. S. / H. S. C.	S	Iowa & Missouri	9,802	19.2
WESTERN STATES (as per U. S. Census—1890).									
157	E	Colorado	3.451,136	R. T.	C. / H. S.	H	Trinidad, Col.	25,000	16.2
901	E	"	138,375	R. T.	H. S.	S	Colorado	1,350	21.8
463	E	Utah	201,890	R. T.	C. C. / H. S. C.	S	Rock Spring, Wyo. / Pleasant Valley, Utah	839	9.3
660	E	"	658,416	R. T.	H. S.	S	Rock Spring, Wyo. / Pleasant Valley, Utah	3,328	11.3
704	E	Washington	157,832	.. . ..	....	S	.....	1,825	25.9
457	E	California	923,694	R. T.	C. C.	S	.. ..	2,436	5.9
751	E	"	424,529	R. T.	H. S. C. C.	S	....	1,250	6.6
CANADA.									
796	E	Brit. Columbia	381,400	R. T.	C. C. C.	S	British Columbia	1,200	7.0
777	E	Ontario	6,212,045	W. T. / R. T.	C. C. C. / H. S. C. C.	S	....	18,535	6.7
364	E	Quebec	4,888,486	F.	C. C. C.	S	Cape Breton, N. B.	16,456	7.5

them to reply intelligently or accurately; while about three hundred gave data more or less reliable, from which the writer has selected fifty-eight as seeming most trustworthy. The sub-divisions of the United States census of 1890 have been followed.

Table No. 1 gives the road by index number, the State where located, the car-miles, kind of boilers, engines, and coal, the field from which coal was obtained, the long tons of coal used in the given fiscal year, and the pounds of coal consumed per car-mile.

Table No. 2 gives the average, highest, and lowest pounds of coal per car-mile, grouping the roads by territorial sub-divisions and kinds

of coal, with the number from which the averages have been calculated.

Table No. 3 gives the average, highest and lowest pounds of coal consumed per car-mile for different classes of engine plants, with the number of roads from which the averages have been calculated.

While the ton-mile should properly be the basis, yet the difficulty of determining the number of ton-miles has led to the adoption of the car-mile as the best practical unit of comparison.

TABLE No. 2.

AVERAGES.—NUMBER OF ROADS AND AVERAGE POUNDS PER CAR-MILE.

LOCALITY.	Number.	Pounds Per Car-Mile.		
		Highest.	Lowest.	Average.
ALL ROADS.				
North Atlantic States	26	23.7	5.0	10.65
South Atlantic States	4	14.5	7.5	9.95
North Central "	18	22.4	9.5	15.97
Western "	7	25.9	5.9	13.86
Canada	3	7.5	6.7	7.2
Totals and Averages	58			12.46
ROADS USING SOFT COAL.				
North Atlantic States	20	19.5	5.0	10.01
South " "	4	14.5	7.5	9.95
North Central "	18	22.4	9.5	15.97
Western "	6	25.9	5.9	13.46
Canada	3	7.5	6.7	7.2
Totals and Averages	51			10.38
ROADS USING HARD COAL.				
North Atlantic States	6	23.7	8.1	12.78
South "	.	...	...	.
North Central "	..	....	...	.
Western "	1	....	..	16.20
Canada	..	....	...	.
Totals and Averages	7			13.27

TABLE No. 3.

AVERAGES (AS PER GROUPING OF ENGINES).

ENGINE PLANT.	No. of Roads.	Pounds Per Car-Mile.		
		Highest.	Lowest.	Average.
C	9	22.0	9.2	14.5
C.C.	7	13.4	5.0	9.2
C.C.C.	7	10.9	5.2	8.0
H.S.	13	23.7	7.5	15.0
H.S.C.	3	16.5	9.4	13.7
H.S.C.C.	3	19.5	5.4	10.5

Note :—

F. = Flue.
V.T. = Vertical tubular.
R.T. = Return "
W.T = Water tube.
V.W.T. = Vertical water tube.
C. = Corliss.
C.C. = " condensing.
C.C.C. = Corliss compound-condensing.
H.S. = High speed.
H.S.C. = " " condensing.
H.S.C.C. = " " comp'd-condensing.
S. = Soft coal.
H. = Hard "

THE TIMES AND CAUSES OF WESTERN FLOODS.

By James L. Greenleaf.

THE prime factors governing the chronological distribution of flow from any drainage basin are the two prominent climate features,—namely, the variation in the intensity of rainfall and of temperature through the successive seasons of the year. The relation between cause and effect is so direct in this case as to be obvious to all; indeed, the statement may almost be classed with the axioms of science. Should it chance, however, to need the endorsement of a "Q. E. D," such is readily found in the chronological table for the Mississippi presented on another page.

Working behind the two prominent causes, modifying and blending their effects with infinite complexity, are a great variety of features of climate, soil, and topography. Among the more prominent are the hygrometric state of the atmosphere as affecting evaporation from land and water surface, the sandy or the impervious structure of the ground, the character of vegetation, the hilly or level nature of the country, and the proportion of swamp and lake surface to dry land. A moment's thought will suggest how these conditions may, in a secondary degree, modify, not only the amount, but also the time, of high or of low water. For example, certain of them may retard or facilitate the "run off" of heavy rains, and others, by a delicate adjustment, may determine whether the lowest water of the year shall occur in the freezing weather or when evaporation is most active. These features of climate, soil, and topography sometimes—to borrow an illustration from the field of politics—hold the balance of power between the two predominating factors which control the flow, and stand ready to cast the weight of their influence in either direction. The effect of the secondary factors is so subordinated, however, in taking a broad view of the Mississippi system, that, in its case at least, rainfall and temperature are the only two causes which can profitably be related to effect when studying the chronology of discharge from its water-courses.

The country drained by the Mississippi is topographically divided into several large water-sheds, each named from its most important river. They are too familiar to require description, but it may be well, in passing, to recall them, and state their respective sizes.

THE DRAINAGE AREAS OF THE MISSISSIPPI AND TRIBUTARIES.

The Upper Mississippi (to the mouth of the Missouri)	173,000	square	miles.
The Missouri	528,000	"	"
The Ohio	214,000	"	"
The Arkansas	161,000	"	"
The Red	97,000	"	"
All other tributaries, of which the St. Francis, White, and Yazoo are chief	86,000	"	"
Total of the Mississippi water-shed	1,259,000	"	"

Although this topographical division into the several water-sheds of the principal tributary rivers has been wrought by natural causes, one is tempted to depart from it in the present study, and deal instead with what may be called climatic areas. The inducement is that

climate to a great extent ignores water-shed lines, and groups parts of adjoining river basins under the same circumstances of rainfall and temperature. For instance, the upper waters of the Arkansas and Missouri are, broadly speaking, subject to somewhat similar winter conditions, markedly different from those active in the regions about their mouths; and, again, the Yazoo, St. Francis, and, to a certain extent, the lower waters of the Arkansas, drain a belt of country characterized throughout by a heavy winter and spring rainfall. Nevertheless, for clearness of treatment, it is advisable to adhere to the divisions into the tributary water-sheds, whose names are familiar and convey definite ideas of locality. These water-sheds are arranged in the table here presented in four groups, which, as far as possible, cluster the rivers according to their pronounced characteristics of flow-period and climate. The fifth division is an analysis of conditions existing in the extreme northern part of the Upper Mississippi water-shed. The table is simply a condensation and grouping of the prominent facts,—those truths which stand out in clear relief upon the mass of detail concerning the chronology of flow.

We read from the table that all the rivers tributary to the Mississippi show a decided tendency toward low water in the autumn. The southern rivers begin to fall from a high stage in June, and the northern rivers in July. All begin to rise from low water in the winter. The southern tributaries show a decidedly increased flow in January, the Ohio in late January, the Missouri and Upper Mississippi in February. Two principal freshets occur during the year in each of the large tributary basins. Considered broadly, and for all the large tributaries, the period from February into June covers the time of occurrence of the two highest stages of the year. Between these two stages of especially high water, a fair and even high state of flow is maintained. There is a tendency for the higher of the two rises to occur in late winter or early spring on the southern tributaries, whereas the Upper Mississippi and Missouri reach their yearly culminations in the latter part of spring and summer. The coincidence of highest stage in more than two of the large branches is extremely rare, and hence it is an exception for the main river to be subjected to the enormously-congested state which would otherwise result.

Such being the prominent facts, it is in order to search for their underlying causes. The first clue to arrest attention is that a decided tendency to a light rainfall in the late summer and in autumn prevails over the entire Mississippi water-shed. It is true that the northern and the elevated regions have their smallest rainfall in the winter, and of this a large part is stored in the form of snow and ice; yet the fall amount comes next in order, and is very light. For the central, and

CHRONOLOGICAL TABLE OF FLOODS AND LOW WATER FOR THE TRIBUTARIES OF THE MISSISSIPPI.*

Tributary rivers.	Comparative rainfalls grouped according to three-month periods.	Time of beginning the rise from the low period.	Time of occasion of the highest stage.	Time of occasion of the next lower flood.	Time of beginn'g of the fall to the low period.	Time of occasion of the lowest stage not due to freezing.	Time of occasion of the winter drop.
Yazoo	Sp. rain,-max (18. ins.) Wi. " (16 ") Su. " (11. ") Au. " (9. ")	January	April	Irregular	June	July to Dec. (leaning to Nov.)	
St. Francis	Sp. rain,-max (12.5 ins.) Wi. " (10. ") Su. " (10. ") Au. " (8.5 ")	January	late March	Irregular	June	Sept. to Dec. (leaning to Nov.)	
White	Sp. rain,-max (13. ins.) Su. " (11. ") Au. " (10. ") Wi. " (8. ")	January	Feb. to May	Irregular	June	Aug. to Dec. (leaning to Sept. to Nov.)	
Red	Sp. rain,-max (11.5 ins.) Su. " (10. ") Au. " (8.5 ") Wi. " (8. ")	January	Feb. to May	Irregular	June	Aug. to Dec. (leaning to Sept. to Nov.)	
Ohio	Sp. rain,-max (12. ins.) Su. " (12. ") Wi. " (11. ") Au. " (8.5 ")	late January	Feb. to March	Apr. to May	June	Oct. to Nov.	
Arkansas	Su. rain,-max (9. ins.) Sp. " (8.5 ") Au. " (6. ") Wi. " (4. ")	January	Apr. to May (sometimes February)	February (sometimes Apr. to May)	June	Aug. to Dec. (leaning to Oct. to Nov.)	
Missouri	Su rain,-max (6.5 ins.) Sp. " (6. ") Au. " (4.5 ") Wi " (3. ")	early Febr'ary	June	April	late July	Sept. to Nov. (leaning to Oct.)	late Nov. into Dec.
Upper Mississippi	Su. rain,-max (13. ins) Sp. " (9. ") Au. " (8. ") Wi. " (4.5 ")	February	Apr. to July	Feb. to March	late July	Aug. to Oct.	Dec.
Mississippi ab've mouth of the Minnesota	Su. rain, max (10.5 ins.) Sp. " (7. ") Au. " (6.5 ") Wi. " (2.5 ")	early April	April to May (sometimes June to July)	June to July (sometimes April to May)	late July	Aug. to Nov.	late Nov. into Dec.
Minnesota	Su rain,-max (12. ins.) Sp. " (7. ") Au. " (6.5 ") Wi. " (2.5 ")	early April	April to May (sometimes June to July)	June to July (sometimes April to May)	late July	Aug. to Nov. (leaning to early Oct.)	late Nov. into Dec.

* When a writer records definite statements concerning variable conditions, he does so at his peril. There are, doubtless, grey-haired rivermen, familiar with the Mississippi from their boyhood, who would drive their stern-wheelers right through the above table, without a moment's hesitation. Moved by a natural desire to avoid disasters of this nature, I may remind those navigators who claim the right of way that individual opinions concerning times of high and low flow are very liable to be influenced by special occasions of freshet or drouth, which have impressed themselves upon the memory. The conclusions here presented, on the contrary, are the result of an impartial study and averaging of the large series of gagings of the various rivers which have been recorded and published by the engineer corps of the United States army and by the Mississippi river commission. They should be understood, therefore, to represent average conditions, from which the rainfall and climate of any particular year may cause wide departures.

particularly the south-central, portion of the Mississippi water-shed the autumn rainfall is the lowest of the year. This widespread condition of light rainfall, occurring at the time when the atmosphere is driest, the power of the sun still strong, and evaporation from the ground most pronounced, readily accounts for the prevalence of low water throughout the Mississippi water-shed in the fall. Further, it becomes apparent, in passing up the center line of the Mississippi valley, that, while in the south the spring rainfall is the greatest of the year with the summer rainfall well up toward it in amount, the order of precedence is reversed further north. This fact, together with the earlier demands of vegetation and evaporation in the south, suffices to explain the tendency of the southern rivers to begin falling in June, and of the northern streams to hold on into July.

The low flow reaches a minimum, as a rule, some time in October or November, upon all the tributaries of the Mississippi. It is often broken by a sudden and uncertain freshet, caused by brief autumn rains. This rise, pronounced though it may be at times, is too erratic to be noticed, except as an incident among the regular changes of the year. Upon the Upper Mississippi and Missouri there is a drop,—for so it is best described,—when winter cold sets in, to what is frequently the lowest water of the year. The sudden falling off in the volume of flow at this season is due to the freezing of the multitude of little water-courses supplying the larger streams, and to the change from rainfall into snow, which is stored until the spring.

The reasons for the times of flood in the tributaries of the Mississippi are more involved than those for the times of low water, and therefore require more comprehensive discussion. Yet it will be seen that they also group themselves about the distribution of rainfall and of temperature,—the two dominant climatic features which have been shown to control the periods of low flow. It will aid one in appreciating the causes which determine the times of high water if he conceives a bird's-eye view of the Mississippi water-shed. Upon this mental picture may now be sketched the conditions of rainfall and of temperature as they change with the succession of the seasons, and the resulting stages of the river can be traced.

The winter rains are especially heavy over the water-sheds of the Yazoo, St. Francis, and White, and upon the lower regions of the Arkansas and Red. The moist air currents which supply these rains have a marked tendency to sweep to the north-east, well up the valley of the Ohio, and make its winter rainfall also prominent. They reach the lower edges of the Upper Mississippi and Missouri water-sheds, but those rivers, as well as the head-waters of the Arkansas, are still throttled by the cold. Evaporation is slight. Where the climate is

not extreme, but where the ground is sufficiently elevated to induce the formation of snow and ice, early thawing swells the streams. Hence the month of January sees the southern rivers rising. The Yazoo and St. Francis, with their heavy rainfalls distributed throughout the year, are well up in late winter, and growing toward a usual maximum in March or April, when the special concentration of rainfall occurs. It may be remarked, in passing, that their water-sheds comprise no elevated land, and are not subject to any appreciable amount of thawing of ice and snow. Partly in consequence of this, there is no particular tendency to the two well-defined periods of high water, with a fall intervening, which will presently be shown to characterize the larger tributaries. One or more falls may alternate with rises, but these are due to irregular variations in the rainfall.

The Red river is rising toward its highest point, which, possibly, it will not reach until the April or May rains have asserted their predominance. The White is showing much this same variation.

The Arkansas, although its upper waters are still locked fast in the mountains, feels the effect of rain upon the lower water-shed. It is affected by two marked differences of condition. The lower regions of the water-shed are subject to features of rainfall and temperature similar in nature, and largely in degree, to those commanding the water-sheds of the Yazoo, St. Francis, and White. The upper waters are frozen fast in winter, and, moreover, the period of special concentration of rainfall occurs upon this elevated region in the summer. Hence the winter and early spring rains upon the lower regions, very slightly subjected to evaporation, and aided by some melting of snow and ice, raise the river to a decided freshet. The late spring and early summer rains upon the upper regions, swollen by melting snow among the mountains in case that is so long retarded, and added to a very considerable rainfall on the lower portion of the water-shed, cause another freshet in late spring. This tendency to two periods of high water is very marked. Essentially similar conditions are in force upon all the large water-sheds tributary to the Mississippi.

Some time in February or March the Ohio reaches its highest flood. This is due to the melting of snow and ice, added to a heavy rainfall. The spring rain is the greatest of the year on the Ohio water-shed, although it cannot equal the effect of the heavy winter rains combined with the thawing of the snow. So the Ohio falls somewhat after the February thaws, only to rise again to the next highest stage of the year with the rains of April and May.

In February the lower regions of the Missouri and Upper Mississippi have felt the rains and thaws and the rivers rise decidedly. Their upper waters, however, are still held back by the winter's cold. The

latter part of February or the early part of March sees the break-up on the Upper Mississippi, which then rises to the second highest stage of the year, largely because of the melting of snow and ice. The heaviest rainfall upon its water-shed is in summer, and it is, therefore, between late spring and July that the highest water occurs. The same sequence is found, six or eight weeks later, at the sources of the Upper Mississippi. The melting occurs there in April or May, and, with the rainfall, causes a freshet. This is succeeded by a lower stage, until the June and July rains once more raise the river. The latter generally is the greatest freshet of the year, but the honors are nearly evenly divided with the spring rise.

The Missouri shows somewhat the same characteristics as the Upper Mississippi. The relative distribution of rainfall through the four seasons is about the same as for that river, but the temperature conditions vary greatly in different portions of the water-shed. The upper waters spring from a high altitude among the Rocky mountains, which retains some of the characteristics of a winter climate long after spring has made itself felt at the sources of the Mississippi. Hence the thawing has effect upon the river until May, and, in fact, snow is still feeding the river in the mountains until June is passed. There is a culminating stage in April, caused by rain-fall and the passing out of the snow and ice, but the greatest rise is in June. This is due to the rainfall of late spring and early summer, which is the heaviest of the year. Then the decline toward the low water of autumn commences.

The Missouri closes the list of chief divisions of the Mississippi system, so that the way is now prepared for gathering the various lines of investigation thus far followed, and, by their means, interpreting the cycle of fluctuations in the main river. The Mississippi reflects unerringly the variations of rain-fall and temperature which occur upon its tributary basins. So much may be assumed as a fact beyond dispute. Yet, even granting an understanding of the rain-fall and temperature, who can say precisely what the stage of the river will be at any particular time? So infinite are the possible combinations of amount, time, and place in the variations of rainfall and temperature over the Mississippi water-shed that minute analysis is futile. Close students of the river may, it is true, follow the flood-waves of any particular year as they pass down the channel, and note the effect of each entering stream upon their progression, but precisely such a series of combinations may never occur again. It is impossible to foretell what the conditions will be for a single season.

Nevertheless, the truth remains that the varying stages of the Mississippi accurately reflect the fluctuations of rainfall and of temperature which occur upon its tributary basins. If heavy rains prevail for

a season in the northern tier of States, they are sure to record themselves in an impulse that reaches to the gulf of Mexico, and a February thaw is noticeable far south of the region of snow and ice.

Ignoring the complicated interactions which carry one so quickly into endless ramifications, and keeping resolutely in mind the broad and simple relations of rainfall and temperature, it is not difficult to interpret the story recorded by the Mississippi. In fact, simply from what has already been outlined concerning its chief tributaries, it is possible to build up, in its bolder features, the yearly record of the main river, and direct examination of the river confirms it.

Preliminary to such a synthesis of the Mississippi, two fundamental truths should be mentioned,—one common to all streams, and the other peculiar to this river. In the first place, as a river is the resultant of its tributaries, the times of its high and low water depend, not only upon the chronology of its tributaries, but as well upon their relative volumes both in high and low water. In the second place, the Mississippi is virtually created by the union at one point of three large rivers,—the Ohio, the Missouri, and the upper Mississippi.

The three most important branches of the main river, thus uniting at its head, naturally stamp their characteristics upon it to a very marked degree, and it bears these features through the entire course to the gulf. The large tributaries further south modify, but cannot control, the overwhelming influence of this triumvirate which presides over the Mississippi valley. To particularize still further, the Ohio should rightly, in a hydrological sense, be considered as the continuation of the main river, for, both in average and in flood flows, it fully equals the combined volumes of the Missouri and the upper Mississippi. It is only when the Ohio falls to low water that its effect is lost among the other streams.

It will be remembered that the Ohio is the first large tributary to raise its flood-wave to the highest point after the winter and spring rains set in. In February or March, as a rule, it pours an enormous volume of water into the Mississippi channel, which is already filling with the increasing flow from other tributaries, and establishes a condition of high water down the entire length to the gulf. Then does the Ohio reign supreme, and set the pace for the opening season of activity. As the Ohio flood subsides, the main river is held well up to high-water mark by the increasing flood-waves from the upper Mississippi and Missouri. Generally the crest of the former is the earlier to arrive, but occasionally their floods are coincident. One or both combine with the waning Ohio to raise the Mississippi, some time in March, April, or May, to its highest point for the year. In the mean time the lower tributaries, and notably the Arkansas, are not

idle, but are doing their part toward maintaining the volume of the main river. Their *rôle*, however, is almost invariably subordinate to the three controlling rivers.

The two periods of flood characteristic of each of the large tributaries of the Mississippi have an important bearing upon the continuance of high water in the main river. By the time the first flood-crests of the upper Mississippi and Missouri have expended themselves, and sometimes coincident with them, the Ohio is discharging the summit of its second flood into the channel. Then occurs in June the highest stage of the Missouri, and about that time, but often in July, appears the yearly culmination of the upper Mississippi. Thus the chances are that, while one river is lessening its flow, another will be rising, and, in consequence, the tendency is for the main river to flow in strong volume until well into the summer. When June merges into July, the southern rivers have fallen, and the activity of the northern rivers is largely past. At this time the state of the upper Mississippi and Missouri determines the stage of the main river.

As the days pass, and the northern rivers follow the example of those further south, the Mississippi, which has been known to discharge two million cubic feet of water per second, may dwindle until its utmost volume is only one-thirteenth part as great. The barren slopes of the levees, standing high and useless on the bank, tell the tale of universal drouth upon the water-shed, and the steamboats struggle with the sand bars which obstruct the channel.

Toward the end of November the Mississippi shows the first signs of awakening energy, and rises moderately, owing to the late fall and winter rains in the south. Soon the Ohio again exerts its influence, chiefly through the two large rivers, the Tennessee and Cumberland, which monopolize the southern portion of its water-shed. As January passes, all the water-courses are rising, except those still locked fast in the snow and ice covering the northern States; and February once more sees the Ohio ready to dominate the entire Mississippi valley.

Thus is completed, in broad outline, the story of the yearly variations in the Mississippi. The river is a result; its tributaries are the cause. Viewed broadly, as has been necessary in this article, a general similarity of behavior is observed; yet each great feeder of the main river has its special cycle of alternations between high and low water; each great line of drainage has its distinctive features of flow. Were the secondary water-courses followed, the vast Mississippi water-shed would be seen covered by countless brooks and rivulets, each affected by local conditions, yet all obeying a few fundamental laws, which gather the waters as in the hollow of the hand, and pour them through a single channel to the sea.

Table of Rainfall and Discharge Data for the Principal Watersheds of the Mississippi System.

Watershed.	Rainfall.										Flow per Second.					
	Annual.		Spring.		Summer.		Autumn.		Winter.		Minimum.		Average.		Maximum.	
	Inches. Depth.	Cu. ft. per sec. per sq. mile.	Inches. Depth.	Cu. ft. per sec. per sq. mile.	Inches. Depth.	Cu. ft. per sec. per sq. mile.	Inches. Depth.	Cu. ft. per sec. per sq. mile.	Inches. Depth.	Cu. ft. per sec. per sq. mile.	Total in 1000's of cu. ft.	Cu. ft. per sec. per sq. mile.	Total in 1000's of cu. ft.	Cu. ft. per sec per sq. mile.	Total in 1000's of cu. ft.	Cu. ft. per sec. per sq. mile.
Mississippi above mouth of Minnesota Riv. (19,500 sq. miles)	27·2	2·000	7·1	2·158	10·7	3·296	6·8	1·994	2·7	0·780	3	0·154	13	0·674	50	2·56
Minnesota (16,000 sq. miles)	28·0	2·061	7·0	2·070	11·8	3·476	6·6	1·944	2·6	0·772	0·5	0·031	7·6	0·474	[1]60	3·75
Upper Mississippi above mouth of Missouri Riv. (173,000 sq. miles)	34·7	2·555	9·0	2·650	12·8	3·769	8·2	2·415	4·6	1·355	25	0·144	118	0·688	550	3·17
Missouri (528,000 sq. miles)	19·6	1·443	6·1	1·796	6·4	1·885	4·4	1·296	2·7	0·795	25	0·047	94	0·178	600	1·14
Ohio (214,000 sq. miles)	43·1	3·173	11·9	3·504	11·8	3·925	8·5	2·503	10·9	3·210	35	0·163	204	0·953	1200	5·61
St. Francis (80,000 sq. miles)	41·3	3·041	12 4	3·652	10·2	3·004	8·6	2·533	10·3	3·033	[2]3·5	0·438	17	2·130	[4]36	4·50
White (28,000 sq. miles)	42·0	3·092	13·0	3·828	11·0	3·239	10·0	2·945	8·0	2·356	4·5	0·161	20	0·750	120	4·29
Arkansas (161,000 sq. miles)	28·3	2·082	8·6	2·518	9·3	2·748	6·3	1·864	4·1	1·207	4	0·024	48	0·300	250	1·55
Yazoo (13,000 sq. miles)	53·3	3·924	17·8	5·239	10·9	3·222	8·9	2·621	15·7	4·615	[3]5	0·384	35	2·749	[4]80	6·15
Red (97,000 sq. miles)	38·3	2,798	11·5	3·386	10·2	3·019	8·4	2·485	8·2	2·400	3·5	0·036	50	0·515	180	1·86
Mississippi above its mouth (1,259,000 sq. miles)											175	0·139	664	0·528	1800	1·43

[1] Probably much exceeded at times.

[2] Obtained from a comparison of the Yazoo and White.

[3] Derived chiefly from gaugings by Captain Willard; checked by comparison with the White.

[4] Result chiefly of a comparison with the White, allowing for differences of rainfall and topography.—Somewhat uncertain.

From an article by James L. Greenleaf, C. E., upon the "Hydrology of the Mississippi," published in the issue of the *American Journal of Science* for July, 1896.

THE CURE FOR CORROSION AND SCALE FROM BOILER WATERS.

By Albert A. Cary.

GENERALLY speaking, no important subject in steam engineering is receiving less intelligent attention from steam users today than the choice of feed-water for boilers and the evils resulting from a bad selection. If absolutely pure water were available from natural sources for boiler use, a consideration of the subject would be uncalled for, but, unfortunately for steam users, such is not the case, and therefore it becomes the duty of owners and operators of steam plants to inform themselves, at least generally, on this subject, that they may reduce their operating expenses by saving fuel and time in cleaning, and by lessening materially the necessity for boiler repairs.

Owing to the fact that water is the greatest of all known solvents, all natural waters contain more or less impurities, and therefore, in making a selection for boiler purposes (if a selection is possible), it is not a question of obtaining a pure water, but of choosing one which contains such impurities as will give the least trouble, or else one containing such impurities as will yield most readily to purifying treatment. If more than one source of supply is available, it certainly will pay the steam user to seek the advice of an experienced expert, before adopting either. Many, most erroneously, infer that, if they have a good drinking water, it must necessarily be good for boiler use. This was well illustrated to me a few years ago, when I found a large steam plant using water from the town supply and having no end of trouble from hard deposits of scale in their boilers. This plant is located on the bank of a large stream, but its water is generally muddy and turbid, presenting an unattractive appearance. A little investigation proved that this stream water was far superior to the town supply for boiler purposes, and the next step was to make provisions to clear it of its suspended matter. I found that the ground on which the plant was built was almost a pure sand, extending to the river-bed. I then had a number of wells driven just outside of the boiler-room. They were rapidly filled from the river, through this natural sand filter, giving a good, almost clear feed-water, causing very little trouble in the boilers.

Probably the purest water obtainable is rain water. Many may think that this should be entered here as an exception to my sweeping statement that no pure water is obtainable from natural sources. I am sorry to say that facts will not support this exception, as

rain water is always found to contain more or less impurities, and the same may be said of hail, snow, mist, dew, or hoar frost. All of these forms of water find in the atmosphere gases and fine floating matter which they eagerly appropriate and carry with them as they fall. Of course, a greater proportion of impurities is found in the neighborhood of large towns and manufacturing centers. Probably one of the most careful researches concerning the purity of rain water was made by the rivers pollution commission of Great Britain. It reports the following as the average obtained from the examination of seventy one different samples of water collected at a farm at Rothamsted, England.

Total dissolved solids.....	3.95	parts in 100,000.
Organic carbon.....	0.099	"
Organic nitrogen.....	0.022	"
Ammonia.....	0.050	"
Nitrogen as nitrites and nitrates...	0.007	"
Total combined nitrogen.....	0.071	"
Chlorine	0.063	"

This list by no means includes all the impurities. Oxygen is often found, and also, frequently, sulphurous and sulphuric acids (derived from the combustion of certain coals). Snow is particularly adapted to absorb these acids from the atmosphere; thus, Sendtner found snow freshly-fallen, in Munich, to contain .7 parts sulphuric acid per 100,000. On the following day it contained 1.76 parts; after ten days, 6.22 parts; and after sixteen days, 9.18 parts.

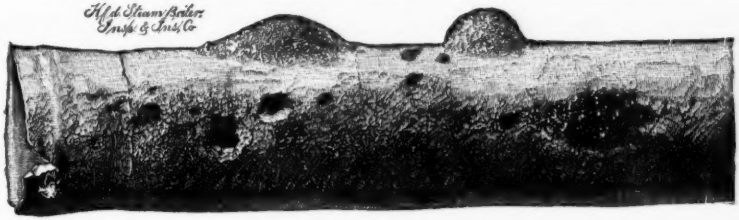
One of the most available places to collect rain water for industrial purposes is the roof of a building. Roofs are generally covered with dust, soot, and other dirt affecting the purity of the water materially; therefore the first rain that falls (which not only cleans the roofs, but also washes out the air to a considerable degree) should be allowed to run to waste. There are devices on the market made to accomplish this result automatically. Notwithstanding all I have said regarding the impurities in rain water, it will be found to be much purer than water obtainable from any other natural source, and, therefore, some steam plants, in which much trouble follows the use of bad feed-water, might substitute, at least partially, rain collected from the roofs.

In Switzerland there are lakes fed principally from the melted ice and snow of the mountains, and in Scotland there is a lake of wonderful purity from which the water-supply of Glasgow is obtained. These waters would be called practically pure, if judged by the residue left behind after evaporation, but, notwithstanding, they are giving a great deal of trouble in boilers, due to excessive pitting.

Pitting may be described as a corrosion occurring in small spots

on a boiler tube, flue, or shell (in contradistinction to a general corrosion which wastes away an extended surface). This pitting action is often very destructive, frequently burrowing holes through a boiler sheet or tube, as though it had been drilled. Pitting has sometimes been attributed to poor material used in construction, the theory being that weak spots exist and are attacked by corrosive agents (found in the water), yielding thereto more readily than the perfect part of the material. There is little doubt that such imperfections would facilitate the action, but this explanation falls short of a satisfactory answer, as it can be fitted to but very few cases.

Careful experiments by Prof. Crace Calvert, repeated by A. Wagner, Scheurer Kestner, Meunier Dolifus, and others, show that pitting occurs when gases are found dissolved in the water, oxygen and carbonic acid gas being the most active destroyers, especially when present together. Gases are very soluble in water, and should be looked for as carefully as dissolved liquids and solids. The waters of the Swiss and Scottish lakes referred to contain a considerable quantity of the gases named above and the serious pitting is due to their presence.



A TUBE PITTED BY PURE WATER.

Considerable air is found dissolved in water, and it is a curious fact that, when thus in water, its original proportion of 1 volume of oxygen mechanically mixed with 4 volumes of nitrogen is changed (owing to the greater solubility of the oxygen), becoming 1 volume of oxygen to $1\frac{87}{100}$ volumes of nitrogen. With the oxygen thus increased the corrosive power of the changed air is accordingly greater. It has been found that air and gases are expelled by thorough boiling.

The destructive action of water having a temperature close to the boiling point is doubtless due to the fact that the contained air or gases have not been removed. Much trouble from pitting has occurred in low-pressure house-heating boilers, owing to insufficient boiling and a circulation too weak to remove the bubbles of gas that attach themselves to the internal surfaces of the boiler. This is also often the case in feed-water heaters and connecting pipes. Cast iron has proved itself superior to wrought iron and steel in resisting this corrosion.

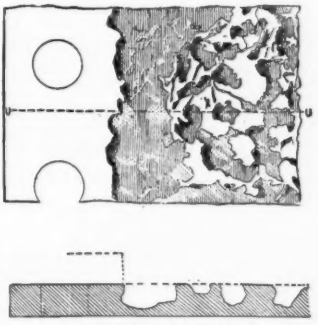
I recently had my attention called to a heating boiler in New York city using Croton water from the city supply. This is an exceptionally good water for boiler use, and therefore it surprised the owner and contractor to find the tubes badly pitted less than a year after the boiler was started. New tubes were put in, but the same bad pitting was found in them a year later.

Lack of good circulation in all parts of the boiler might account partially for this trouble, but further inquiry brought out the fact that, as soon as the weather grew warm, this boiler was put out of service and the water was left standing in it. Then the dissolved air and gases had their opportunity for destructive work without interruption by circulating currents. When such boilers are put out of service for the summer, no water should be allowed to remain in them. They should be blown off while warm, well cleaned, and thoroughly dried either by wiping or by heat. To accomplish this by the latter method, pans of burning charcoal are introduced into the boiler, or a very light fire of paper or shavings may be started upon the grate.

It is not an easy matter to explain the action of these gases producing pitting in a steam boiler. Why is it that isolated spots are attacked, while the surrounding metal is apparently unaffected? When water is slowly heated in open vessels, bubbles of gas or air are seen clinging to the sides or bottom, and, if there is a crack or similar imperfection in such a vessel, it appears to present a wonderful attraction for these bubbles, more collecting there than elsewhere. Again, these bubbles seem to place themselves with a very fair degree of regularity, as far as their distance apart is concerned, and, if any certain area is cleared, that space seems to have a special attraction for new ones. Considerable agitation fails to remove these bubbles, which cling tenaciously to their selected places. In boilers there is little doubt that these bubbles contain gas in a favorable condition of moisture and temperature to act rapidly on the metal beneath. After eating a little pit and exhausting their oxygen, they leave behind, in the pit, oxid of iron, which occupies more volume than the original iron acted upon. In consequence, the pit is more than filled, and a little boil-like excrescence appears. Expansion and contraction break up this oxid deposit, thus preparing this same spot to attract the next little bubble of gas, which, in turn, does its work, and this action continues, until a hole is corroded entirely through the metal.

Sometimes a considerable number of these pits occur very close to each other, giving the metal almost a honeycomb appearance, but this is less frequent than a scattered form. As a remedy for this trouble, probably nothing is more effective than the deposit, in a boiler, of a slight lime scale on which the corrosive agent contained in these

bubbles can exhaust itself. If this slight deposit cannot be effected by using the regular feed, or natural water available from some other source, a solution of milk of lime can be fed into the boiler along with the feed-water, and this will soon form the required internal coating.



A HONEYCOMBED PLATE.

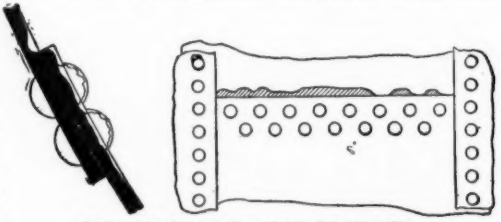
Some have attributed pitting to electrolytic action set up between the impurities in the iron (occurring at small points) and the iron of the boiler itself; the iron, being electro-positive to the impurities, gradually disappears, while, of course, the impurities remain unaffected to further this destructive action. If this is the correct explanation, zinc should be suspended in the boiler and connected most carefully with the boiler shell by copper wire, when the zinc (which is electro-positive to iron) will disappear gradually, and, in so doing, will protect the iron. The writer has never adopted this theory, and his success in overcoming pitting troubles in boilers, working on the assumption that this trouble is due to the presence of gases in the water, goes far with him to support the correctness of that theory, which has also been confirmed in many other ways.

There is one other form of corrosion which limits its action to certain local spots, or, rather, lines, in a boiler, known under various names, such as grooving, channeling, and furrowing. This subject is almost foreign to this article, which considers merely boiler waters and the troubles resulting from their use, and it might be placed more properly under the heading of bad design; but, as it facilitates greatly the corrosive action of bad feed-water, a few words will be of interest here.

Grooving in boilers nearly always occurs at such parts of the metal as are subjected to an excessive alternate bending backwards and forwards, as the pressure and temperature of the boiler changes; less frequently, it is due to bad or excessive caulking of the seams or joints.

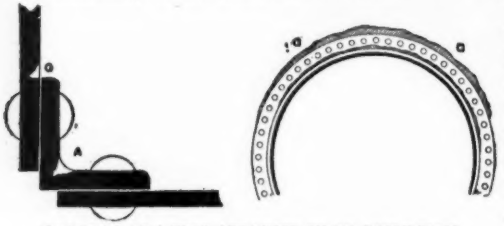
When the metal is continually bent backwards and forwards, it sooner or later develops a crack, which opens its skin, thus exposing an inner line of unprotected metal to any corrosive agent in the water. After this exposed surface is attacked, an oxid of iron or other formation covers the metal and in a great measure protects it from further corrosion, but, as the flexing continues, the protecting coat soon cracks off, allowing the corrosive agent to attack a newly-exposed line of metal

immediately below the original surface, which continues until the groove is developed and finally the boiler becomes unsafe, which condition has frequently been followed by disastrous explosions. This excessive bending action in the metal of boilers is due chiefly to bad design. Either too great rigidity is found immediately adjoining a flexible part, in which case the latter is subjected to buckling under the great strains to which boilers are necessarily subjected, or else some part is not sufficiently stayed or strengthened to prevent a considerable change in shape from taking place under the pressure carried by the boiler. Both extremes can be avoided by a careful designer.



GROOVING AT A LAP, CAUSED BY BENDING.

We often find grooving next to a heavy riveted seam and nearly parallel to it, and it is also found next to heavy reinforcing rings and saddles used to strengthen the shell where holes have been cut. Where the flat surfaces of boilers are stayed too rigidly by gussets, braces, or other forms of stays, we find grooving near their fastenings. This occurs very frequently in various forms of flue boilers. Such trouble can be stopped by altering the construction of the boiler, introducing more flexibility where it is needed—sometimes a very difficult matter.

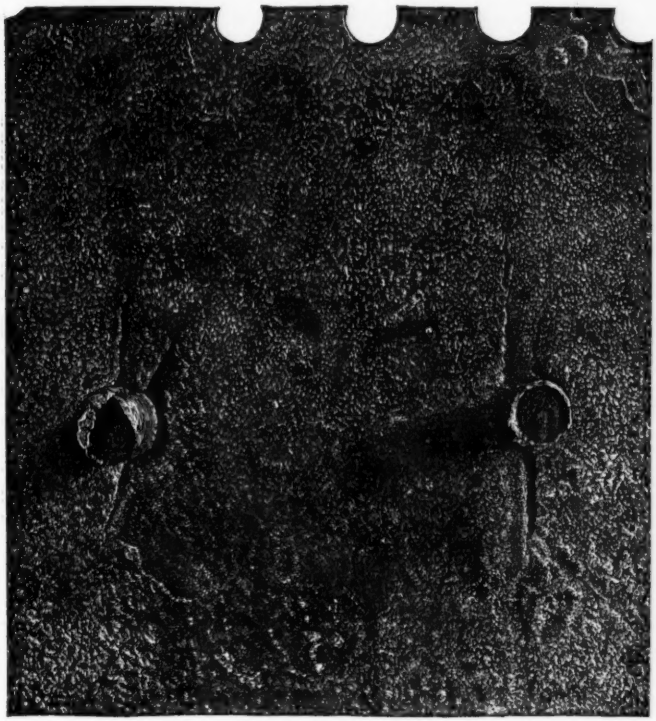


GROOVING OF A TUBE ATTACHED BY AN ANGLE-IRON.

As an example of too great flexibility, we sometimes find boilers having heads insufficiently stayed, allowing considerable bulging action when the boiler is under pressure. This produces alternate bending at the bottom of the curve of the flange by which the head is joined to the cylindrical shell. This bending soon develops a crack, and then the grooving follows. In some cases where insufficiently-stayed flat surfaces are riveted to angle irons, the flexing takes place in the bend of the angle iron, soon developing the troublesome crack. This also occurs occasionally where large flues are attached to the end-heads of

boilers with angle iron. The trouble from insufficiently-stayed surfaces can usually be remedied by the careful placing of new stays, sufficient to prevent undue distortion of the part affected.

The other trouble is generally due to the use of continuous straight riveted flues, which, in service, are highly heated along their upper part, while their bottom part is comparatively cool. This produces an



CORROSION AROUND STAYBOLTS.

inequality in the lengths of the two parts, causing what is known as "arching" of the tube, from which necessarily results bending in the connection between the end of the tube and the flat ends of the boiler, which in turn is followed by grooving. In such cases flexible flues, the corrugated flue, for instance, should replace those having the ordinary lapped and riveted seams.

I have spoken of grooving following bad or excessive caulking. By such work the skin of the metal is broken, and the sheet is more or less deeply scored near the edge of the lap seam. Corrosive agents soon concentrate their efforts along such places, and leave behind the furrow.

When a crack appears in the metal of a boiler, it does not always follow that it is going to develop into a groove or furrow ; that depends entirely upon the character of the water used. Should no corrosive agent be present, the crack would often remain so small as to escape the notice of an inspector; but, as the bending continues, the crack generally grows deeper, until it becomes dangerous. The width and depth of the grooving depend entirely upon the amount of corrosive matter held by the water, both increasing together.

We have now considered the two special and marked forms of corrosion, and next come to the most usual form, known as general corrosion. This is simply the wasting away of the boiler parts. It is most erratic in its actions, occurring sometimes with a fair degree of uniformity throughout the entire surface of the boiler in contact with the water, but most frequently in patches, small or of considerable area ; but in such cases there is so gradual a merging from the corroded to the solid plate that it is impossible to define the exact limit of the deterioration. This is a distinctive feature of general corrosion.

Sometimes we find a band of more or less width etched around the boiler shell, its position coinciding with the "water line" or upper surface of the water in the boiler, while its width is determined by the rise and fall of the water-level as allowed by the water tender.

Rivet-heads are often found wasted away to a dangerous extent, and often in such cases the metal sheet around this head is found corroded, but in such a manner as to leave a circle of metal intact immediately beneath the head of the rivet, presenting such an appearance that an inexperienced inspector would easily mistake this "boss" for a part of the head itself, and thus miscalculate the dangerous extent to which the rivet had been corroded. Braces and stays are often found badly "eaten away," and no part of the boiler seems to escape.

General corrosion does not always stop at the surface of the water in the boiler; we sometimes find it occurring on the surfaces in contact with the steam, and even in steam pipes leading from the boiler.

Frequently corrosion and scaling occur together in boilers, and, when a corroded place is thus hidden, it becomes all the more dangerous, as the man inspecting the boiler is apt to pass it over, and, under a feeling of false security, nothing is done to prevent further corrosion. Fortunately, in many cases the scale which covers the corroded spot cracks, and "bleeding" occurs along these lines, this coloring coming from the iron rust,—an indication of what is going on beneath.

CORROSION DUE TO CONTAMINATED WATER.

The only safe way to determine the extent of corrosion is by drilling holes through the plate. To show how easily one may be deceived in attempting to obtain this information in any other way, I might describe the experience of a certain engineer who found the corrosion in a shell extending to the edge of a lapped and riveted joint. He first measured the thickness of this plate from its surface, along its edge, to the surface of the adjoining plate. To his surprise, he found the plate, by this measurement, to be of its original thickness, notwithstanding the very apparent corrosion. Investigation afterwards showed that the adjoining plate was also corroded to a depth equal to the depth of corrosion in the first plate (which accounted for his surprising measurement), while the wasted rivets appeared the same as originally, for the reason already given.

Many explanations are offered as to the cause of boiler corrosion in all of its peculiarities, and probably none more frequently than the electrical theory. This is especially true among our marine friends. I have already alluded to this theory, following my remarks on pitting, and, although not wholly converted to it, I believe that this article would be incomplete without an attempt to make it clear. I certainly do not wish to deny that electric action occurs in boilers, similar to that occurring in a voltaic cell. This has been proved beyond question by the use of a delicate galvanometer, but the strength of the current thus generated is certainly very seldom sufficient to cause so vigorous wasting away of boiler parts as is often found. For example, a current is generated by the difference in temperature between the top and bottom of certain internally-fired boilers, or between different kinds of metal used in and about a boiler, such as a steel shell and iron or brass tubes or composition fitting.

Again, we find a current set up between different parts of the same metal, where a certain portion is sound and homogeneous, while another is poorly made, containing impurities common in bad iron.

In such cases and many more conceivable ones, our electrical friends tell us, two of the parts considered are electrically opposed, one becoming electro positive and the other electro negative, the former wasting away, while the latter remains scarcely affected. They claim, further, that, if zinc be placed in the boiler, a much stronger current is established between it and the shell than exists elsewhere, and therefore the zinc becomes electro-positive to the entire shell and protects it at its own expense as long as this current is amply strong.

Being now led to the subject of applying zinc in boilers for their protection from corrosion, and this being a practice largely followed (especially in marine boilers), the principles of its application and working should be clearly understood. It will then be seen that zinc is by no means applicable to all cases, and may even do more harm than good when misapplied. The electrical theory just described need not be considered in this connection.

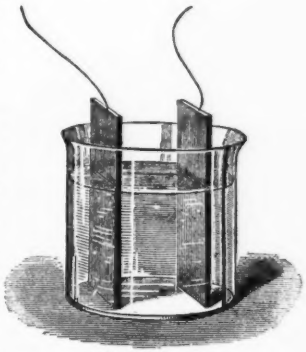
When zinc is placed in a boiler, it must be remembered that we are trying to construct a huge voltaic cell (or electric battery, as many popularly term it). Let us now examine a simple voltaic cell, and the requirements for its successful working.

We find a glass jar nearly filled with a liquid in which are placed two plates, the greater part of which are immersed. At the dry end of these plates copper wires are found, securely attached.

The liquid into which these two plates are plunged is always composed of two or more elements, and, when a voltaic current is made to pass through it, a separation of the elements takes place.

This process of decomposition by the electrical current is called electrolysis, and the liquids thus split up are known as electrolytes.

All liquids are not electrolytes; many oppose the passage of the current so effectively that the plates are practically insulated, and then, of course, no decomposition can occur. Pure water is a poor conductor of electricity, and for that reason we never find it used alone in voltaic cells; a little sulphuric or other oxidizing acid is added, or some of the metallic salts, making good electrolytes.



A VOLTAIC CELL.

We now have before us the essential requirements for the construction of a voltaic cell, but, before assembling the parts in order to study the working, I call attention to the result that follows the passage of a current of electricity through water. Let us suppose that we have an available wire condutcing a current of electricity. Let us cut this wire, and place the two ends thus obtained in water. As water is a poor conductor, we had better add a little sulphuric acid, which will increase its conductive power considerably. We now observe that bubbles of gas are rapidly forming on the immersed ends of our wire; should we collect these bubbles as they rise and escape from the liquid, we would find them to be simply oxygen and hydrogen (the constituents of the water). The oxygen will be found collecting on the wire through which the current enters the water (known as the positive pole), while the hydrogen will collect on the other wire (or negative pole). If such a decomposition does not take place, the fluid does not conduct the current.

For our next step, we will construct a voltaic cell, and, in order to produce a rapid chemical action, both on the plates and in the liquid, we will make our solution of sulphuric acid somewhat stronger than before, and will select zinc for the positive plate and wrought iron for our negative. If the zinc were perfectly pure, no action would take place on immersion in the solution; but commercial zinc is never pure, and, as we are supposed to use this, we find that our zinc plate is attacked the moment it is placed in the liquid, and, as it dissolves away, a large quantity of hydrogen bubbles are given off from the surface of the metal. Next let us immerse our iron plate; we find at once that this is also attacked, hydrogen bubbles rising from its surface as the metal wastes away.

Next let us connect the two copper wires attached to the upper (or dry) ends of these plates; we note at once a change of conditions. The bubbles of hydrogen will still be seen to come from the iron plate, but the plate will not be dissolved. The zinc plate, however, will gradually disappear, but, as long as any part of it remains in electrical connection with the iron, the latter will be protected at the former's expense. The zinc is said to be electro-positive to the iron, or, as some of our chemical friends express it, it is chemically more powerful than the iron. I might call attention to a common practice of protecting iron from rust and corrosion by coating it with a thin film of zinc. This is known as galvanizing; it depends largely upon the principles just described for its successful working.

It is almost unnecessary now to state the reason for the wasting away of the positive plate. It is simply that, as water is decomposed by the passage of the current through it, the oxygen is attracted to the positive plate, and, as electrolytic oxygen (or ozone) is very active in its attack upon metals, we find them more or less rapidly wasting away. Where sulphuric acid ($H_2 SO_4$) is used, we find, after its decomposition, that the hydrogen (H_2) has been attracted to the negative plate, while the corrosive sulphur and oxygen (SO_4) have been attracted to the positive plate.

We can now readily understand the action of zinc in boilers. We might, for example, suppose our iron plate, which we have been using in our experimental cell, to be of sufficient length to be bent into a cylinder in which to suspend the zinc plate by means of a copper wire. This done, we can immerse these in our electrolyte, and we have our cell complete, as before, and also a miniature boiler, without heads.

From this explanation it will be understood that zinc can be used successfully in boilers only when certain conditions preëxist. Some solution must be found which will make a good electrolyte. This condition is often satisfied by the presence of free acid. Sea water makes a good electrolyte, and, in consequence, we find zinc in extensive use in marine boilers. The writer knows of a case where salt was added to a fresh feed-water, in order to make it a good electrolyte. Many other solutions are found in feed-waters, making them good conductors. Another condition of paramount importance for the successful application of zinc is a sure and lasting electrical communication between the zinc and the shell of the boiler. A copper wire or an iron supporting piece attached to the zinc is generally used for this purpose. One can easily understand that, the moment this electrical communication is broken, the zinc ceases to protect the boiler, and corrosion wastes away both the boiler and the zinc.

To secure this electrical communication much time, thought, and

money have been expended; yet we constantly hear of failures in the use of zinc due solely to interruption of the communication.

Zinc plates are often suspended by means of iron straps or clips bolted to them, and are liable to become separated soon by the corrosion on the surface of the zinc; the voltaic current is thus weakened by the resistance introduced between the iron and the zinc, and finally it ceases altogether. Probably one of the best devices invented to overcome this trouble originated with Hannay, who called it "the Electrogen." It consists of a zinc ball having the copper conductor cast through its center; in the process of making, the copper is fused, becoming mixed with the zinc and forming an actual brass. The ball is well hammered, at a certain temperature, thus condensing the metal and insuring its long existence. When the electrogen is suspended in the boiler, the free end of the copper wire is firmly soldered to the shell, and thus a positive electrical contact is attained,

Thus far we have considered the use of zinc for preventing corrosion in boilers; now we want to know how it affects scale. This more properly should be considered after investigating the properties of the different boiler scales, but, to allow the answer to follow the question (which naturally appears here), I will say that there are certain scales, such as those formed by the precipitation of carbonate of lime and carbonate of magnesia, which are not very compact, but open, porous, and easily penetrated by the water. The water easily reaches the shell through them, and, when it is decomposed by the voltaic current, the hydrogen bubbles, which appear on the iron, soon form a film of the gas, which interposes between the plate and the scale; then follows the flaking off of the crust, piece after piece, until the greater part is removed.

Other scales, such as those formed of the sulphate of lime, are hard, tenacious in their hold on the iron, and totally impervious to the water. Under such conditions this necessary film of hydrogen gas will not form between them and the boiler shell, so that they adhere to the firm metal beneath, which has been protected from corrosion by their presence.

None but the purest zinc obtainable should be used in boilers. All commercial zinc contains more or less impurities, and these may become a source of absolute danger when present in any appreciable quantity. Lead is often found, and, after the zinc has wasted away, the remaining lead and the iron composing the boiler become an electric couple, the shell being the electro-positive plate, which begins to waste away as the oxygen bubbles form upon it, while the lead, of course, remains unaffected by the hydrogen.

Electric batteries have been used to accomplish results similar to

those obtained with zinc in the boiler, and with equal success. With this arrangement, the two wires from the cells were led to the boiler, and one was attached carefully to the boiler shell. The second (the positive-pole of the battery) was carried inside of the boiler and terminated with a metallic plate. The action which follows has already been described in the case where the cut ends of a wire, conducting an electrical current, were plunged into a vessel of water.

A concern in Cardiff (Wales) has gone even further than this, supplying the current from a dynamo, and it claims to obtain superior results by reversing the current periodically, so as to change the immersed or suspended plate from positive to negative, and then back again. It claims that it makes the suspended plate electro-negative to the shell to facilitate the disintegration of the scale and hasten the mechanical action of the hydrogen in flaking it off, and also to prevent the polarization of the shell and tubes. This latter process is somewhat questionable, and the writer, before accepting it as good practice, prefers to see these claims proved by more extended use.

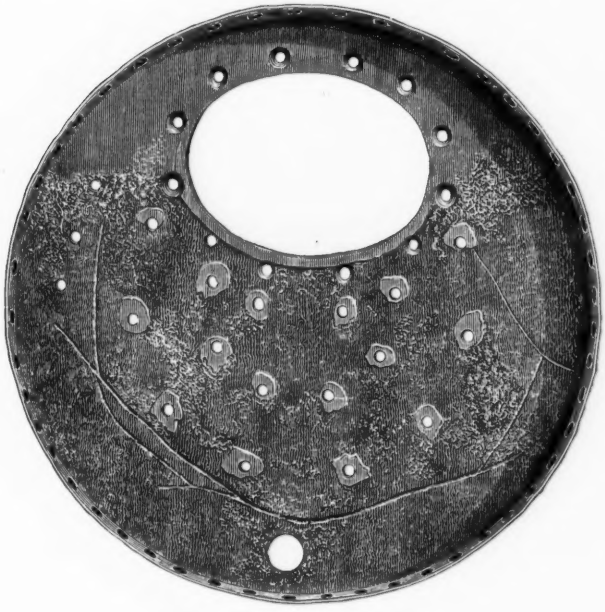
Having considered electrical action in connection with boiler corrosion, now it will be well to find what is contained in boiler water to produce corrosion. We have already considered the presence of gases in boiler water, and their very destructive effects. When corrosion is found in boilers, especially if generally distributed, free acid in the water is looked for first. This acid may be derived from a great variety of sources. I have already spoken of the sulphuric acid absorbed by rain water and snow, from the atmosphere. When we come to the consideration of scale-producing impurities contained in feed-water, we shall find that chlorid of magnesium is often present.

At all temperatures found in boiler practice, this troublesome salt decomposes, as shown in the following chemical formula :

Magnesium Chlorid.		Water.		Magnesium Hydrate.		Hydrochloric Acid.
$Mg\,Cl_2$	+	$2\,(H_2\,O)$	=	$Mg\,H_2\,O_2$	+	$2\,(H\,Cl)$

The hydrochloric acid (or, as it is sometimes called, muriatic acid) is vaporized and passes off with the steam ; thus its destructive action takes effect, not alone in the boiler, but in the steam pipes, valves, cylinders, etc.

Boilers supplied with water from mines are often badly corroded by the large quantities of saline constituents, especially sulphates, derived from the oxidation of pyrites and other sulphids. When calcium carbonate is absent, free sulphuric acid often exists in these waters, accounting for the destructive action, more or less energetic, which follows its use. Certain springs and streams in volcanic districts are found to contain free sulphuric acid. Sulphur dioxid occurs in vol-



CORROSION FROM MINE WATER.

canic gases, and these, when dissolved in water, gradually absorb oxygen from the air and pass into sulphuric acid. A notable example of this kind is found in South America, where the Rio Vinagre (which received its name on account of the acid taste of its water) contains free sulphuric acid from the volcanic springs which feed it.

Streams following through manufacturing districts are often found to be acid, with the refuse poured into them from dye works, galvanizing shops, chemical factories, etc. Such waters should be very carefully examined before being used in boilers, and the acid should be neutralized thoroughly by treatment with proper alkalies, or, as proper treatment is difficult on account of variable composition, water from another source should be obtained, if possible. I know of cases where boilers have been very rapidly destroyed by use of such water.

CORROSION FROM MINE-WATER. SECTION OF THE HEAD SHOWN ABOVE.

Vegetable acids, which corrode the boiler parts, are often found in waters from swamps or bogs. Soft waters (containing little mineral matter) seldom pass any considerable distance from their source before entering a district where vegetation exists, and then, on account of their great solvent power, they readily dissolve the peat or other organic matter found in the woods and fields. It is true that these are but feeble acids; nevertheless they attack the boiler plates, and the slimy nature of the salts produced by such attack causes them to form an objectionable incrustation. As oxygen also is usually present in these waters, pitting is liable to occur, and the vegetable acids seem to supplement and assist in the corrosion, after the manner of carbonic acid, the action of which has already been described.

There is another source from which free acid is sometimes introduced into the boiler feed-water,—one not generally known. Many

CORROSION FROM SWAMP-WATER.

plants in this country are using kerosene in their boilers for the purpose of removing, or preventing, incrustations. Serious corrosion has often followed the use of this oil, and it has puzzled many thinking men to account for it.

Kerosene, produced by a series of distillations from petroleum, is at first a bluish, turbid liquid with a very strong odor. The odor, color, and turbidity are removed by treatment with sulphuric acid, which settles down with the impurities as a heavy black liquid, and is withdrawn to the sludge acid tank. The oil is next washed with water, treated with caustic soda to neutralize the acid, and again washed with water. Next, in order to volatilize any traces of light oils present, the oil is agitated by pumping air through it by a spraying process. In this way the brilliant white illuminating oil with which we are familiar is produced.

Unfortunately, for many who have seriously injured their boilers, this process (though amply able to accomplish the desired results) is sometimes conducted carelessly, so that some acid remains. The oil, when in the boiler, volatilizes and passes off with the steam, while the acid, which remains behind, concentrates (as additional oil is fed to the boiler), and corrosion begins.

I know of certain plants that have experienced this trouble, where use of kerosene continues, but, by alternating it week by week with an alkali (such as the carbonate of soda), all trouble is avoided.

Another source of trouble in boilers is the presence of oil and grease which have been used for lubricating purposes. These accompany the condensed water, formed from the exhaust steam, so often returned to boilers. I have also known of cases where those in charge of boilers, ignorant of the different compositions of the various oils, have actually fed into boilers some of the most dangerous oils, for the purpose of removing and preventing incrustation.

It should be remembered that many of the lubricants used on engines, pumps, etc., are compound oils,—that is, mineral oils mixed with some one or more of the animal or vegetable oils for the purpose of increasing the viscosity. These admixtures are known as "fatty oils." and it is well known that, after exposure, they often become rancid,—in other words, undergo partial decomposition, producing free fatty acids which exert corrosive action on metal surfaces.

We have now traced the principal sources from which the free acids found in boiler waters are derived. It is, perhaps, an unfortunate fact that acids never cause a boiler to prime or foam, and thus give notice of their presence, as do some of the alkalis; I once heard a man in charge of a boiler plant remark that, for the reason just given, he thought a little acid in a boiler a good thing. This man shortly afterwards nearly ruined a boiler by feeding in muriatic acid for the purpose of removing its scale.

The presence of acid in a boiler may sometimes be detected by drawing a sample in a glass from one of the gage-cocks and immersing in it a slip of blue litmus paper. This paper may be obtained at any drug store. A more delicate test may be made by introducing in each boiler about two ounces of phenol-phthaleine. If no acid is present, the water in the gage glass becomes faint pink in color, but, when there is acid, this color weakens, and may even vanish entirely. Of course, blowing off or leakage about the boiler will also cause this color to fade away; otherwise, it would remain in the boiler as a splendid indicator of the presence of free acids.

Whenever boiler water is found to contain free acid, it should be treated with an alkali, such as the carbonate of soda, and the quantity

used should be only in slight excess of what is actually needed to completely neutralize the acid.

Corrosion in boilers has also been traced to the use of water contaminated with sewage and the drainings from privy vaults. The presence of ammonia in some form (probably as sal ammoniac) seems to be responsible largely for this corrosion. When sal ammoniac is concentrated to any great degree, it is a very active corrosive agent.

A TUBE CORRODED BY CONTAMINATED WATER.

Before leaving this branch of the subject,—the gradual wasting away of boiler parts,—it is well to consider the action of rusting. Iron in all its forms has a great affinity for oxygen, combining with it under nearly all conditions and forming what is commonly called rust. In some cases this rust is seen to "penetrate" the iron in spots, while in other cases the whole metal seems to change from its simple metallic state into a red, yellow, or brownish substance, which crumbles away on being handled.

In the ordinary course of corrosion, it is found that oxygen combines with iron in two different proportions, one forming the protoxid of iron, in which one atom of oxygen combines with one atom of iron (Fe O), and the second forming the sesquioxid of iron, in which three atoms of oxygen combine with two atoms of iron ($Fe_2 O_3$). Should we expose a bright piece of iron to a damp atmosphere, it would be covered eventually with a bright red coating of rust. This is the sesquioxid of iron ($Fe_2 O_3$). Removed from dampness, and under cover, the rust soon turns from red to brown. Why is this? Simply because this sesquioxid of iron has given up its third atom of oxygen to the iron, forming a new molecule of the protoxid at the expense of the metal. Now, if this be returned to the damp atmosphere, the red oxid will appear again (indicating the sesquioxid), and under alternating conditions this kind of action continues until the whole plate is affected or "eaten away."

The second paper on this topic, which will appear next month, will treat of the causes and remedies for scale and incrustation in boilers.

Thanks are due to the courtesy of the Hartford Steam Boiler Inspection and Insurance Co for the use of many of the cuts used in illustrating this article.

STANDARDIZING THE TESTING OF IRON AND STEEL.

By P. Kreuzpointner.

II.

IN the previous article on the subject under discussion it was endeavored to point out, numerically, the value and merits, or demerits, of various test-sections as measures of the quality of steel for structural purposes. In the present article it is sought to emphasize and strengthen the conclusions reached, numerically, by graphic illustrations of the phenomenon taking place in the steel, when under tension, of which phenomenon the numerical results are the exponents.

If thus we can picture, as it were, the flow—or degree of viscosity, which is the same thing—of a given piece of steel, we can form a clearer perception of the reasons why different test sections give different results, although the material from which the test-pieces were taken is the same in chemical and physical properties in every respect. Incidentally also, a graphic illustration of the causes producing a variety of results with the same material, due to variations in test-sections, is, of course, an argument in favor of uniform methods of testing.

As already stated, iron and steel flow under pressure. This being so, it follows that this flow must be subject to certain laws.

Water runs freest through a straight, smooth pipe. If there are bends and shoulders, it will not flow as freely at these points. But, where there are no obstructions, the water will still flow more freely in the middle than on the sides or walls of the pipe, as a river flows faster in the middle than on its shores.

If we substitute a viscid material for the water, we find that it will not flow through a pipe without pressing or pulling, and even then it will stick at obstructions, or, if the orifice is too narrow, will not flow at all, but will clog up the pipe so that neither pushing or pulling will move it. Now, these conditions seem to apply to iron and steel when they are set in motion by pressure. They are springy, resilient substances, within certain limits. When, under sufficient pressure, they begin to flow, they flow more freely in a large, unobstructed mass.

Shoulders and fillets hinder and retard the flow, as an obstruction in a pipe hinders the flow of water. Flow is very sluggish in narrow pieces, and more free in especially long, but wider, pieces.

Thus it appears that the same law that governs the flow of viscid materials governs also the flow of iron and steel.

This law, then, must govern the size and shape of our test-piece,

and, the more we depart from this law, the more faulty and unreliable the results.

Figures V, VI, VII, and VIII are sketches made from samples of boiler steel test-pieces prepared in a certain way—to show the flow of the metal. For convenience's sake, one half of each sketch is left blank, and the scriblines 1 to 11, which were drawn on the highly-polished test-pieces, are shown only on the blank half, but may easily be transferred mentally to corresponding positions on the other half. Thus 1^1 corresponds to 1, and 11^1 to 11.

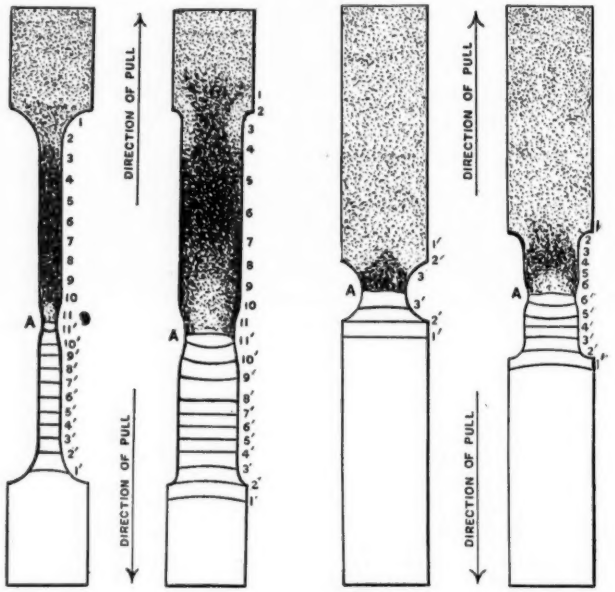


FIG. VI. FIG. V. FIG. VIII. FIG. VII.

A indicates the point of fracture and contracted area. At 1, 2, and 3 we see how the metal began to flow in the middle of the test-piece, and was retarded by the shoulders. The lines 1^1 to 3^1 show this by their slight curvature at the middle, where the flow had been faster. From 4 to 8 flow was uniform, and the lines 4^1 to 8^1 are straight. At 9 flow begins to be more sluggish in the middle, and line 9^1 is curved in the opposite direction. Evidently the sides or edges flow faster toward the end of the test. As a result of this retardation the broken end of the piece is thinner in the middle than at

the edges, as is shown in Fig. IX, which is taken from actual measurement. Analyzing the behavior of the metal, we see the retarding influence of shoulder and fillets. This is recognized by the allowance of clearance from datum point to bottom of fillet, of from $\frac{1}{10}$ to $\frac{1}{4}$ of an inch, so as to have the useful 8-inch section between 4 and 4^1. The portion of the test-piece from 4 to 9 is the really useful and valuable indicator of quality. In soft and moderately hard steels the way in which the portion 4 to 9 stretches after the elastic limit is reached is the criterion of the quality of the metal. At 9 a thickening or clogging of the particles seems to take place, and only some of the outer portions of the metal seem to be pulled down by force. The thickening, clogging, or hardening of the metal when it reaches 9, which corresponds with the maximum load the piece will carry, is sometimes forcibly illustrated by test-pieces with parallel sides, as in Fig. X.

From A to B the metal flows so much as to make the section perceptibly narrower. From B to C the flow has become obstructed by too great a density of the metal; the particles from A to B have flowed into it, and the remaining load, necessary to break the piece, is unable to set the metal, thus condensed or hardened, flowing again.

In Fig. VI, which was cut from the same plate, by the side of Fig. V, we see the retarding influence of fillet and shoulder, as well as of too narrow a section, very clearly. Between 1 and 3 there is hardly any flow. It begins at once at 3, and continues to 10, but evidently clogged, for the total elongation was 5 per cent. less than in Fig. V.

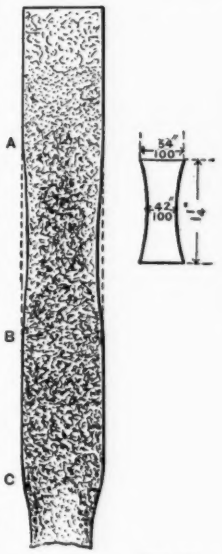


FIG. X. FIG. IX.

Only lines 1^1 and 11^1 are curved, showing same acceleration and retardation of the flow at the begnining and the end of the test. Fig. VII is the old and still much used 2-inch section, where the stretch at the point of rupture takes so much of the useful portion of the test-section as to naturally form the largest percentage of the resulting elongation.

Hence generally speaking, if the elongation in an 8-inch section is 25 per cent., it will be 35 or more per cent. in a 2-inch section.

In Fig. VIII we have the worst form of test-piece that ever existed; happily it is now but rarely used. As can be seen, no flow takes place in the body of the test-piece; it is confined exclusively to the small por-

tion of metal at the point of fracture. Hence the engineer using such a section virtually says: "I do not mind at all what the behavior of my structure is below the point of actual fracture and break-down; all I care to know is at what load it may break."

We are thus forcibly reminded that, as we ascend from the groove or 1-inch section (Fig. VIII,) through any possible variation of forms, to the geometrically proportionate 8-inch section, we come nearer and nearer to the proper and scientifically correct measure of the quality of iron and steel for structural purposes.

Conversely, as we depart from the 8-inch section, our measure of quality becomes more and more unreliable, until finally it becomes a delusion and a snare in the 1-inch or groove section.

It is because of the better understanding of this that engineers more and more abandon the 2,-3,-and 4-inch sections, and adopt the 8 inch section.

This, of course, makes testing somewhat more expensive, because a 2-inch section requires less metal, less preparation, and less time. But what is this comparatively small expense against the increased safety and other advantages gained by a more reliable quality measure?

What are a thousand, or even ten thousand, dollars annually spent in the perfection of methods of testing and examining metal, when the known saving to large consumers, like railroad companies, ship-builders, etc., amounts to a hundred thousand dollars or more on account of prevention of accidents or, at least, reduction of wear and cost of repairs, and avoidance of delays, annoyances, vexations, not to say costly wrecks, due to increased ability to select the best grade of metal for a given purpose for the same price, because of better insight into the properties of metal and the selection of the right measure of quality.

Summing up, then, the results of our inquiry, we find:

(1) Structural iron and steel have all the characteristics of mineral substances of a viscid nature.

(2) The flow is more free and natural and less retarded in large than in small sections.

(3) Hence, in order that the metal in the test-section may exhibit the same degree of flow (which is the measure of quality of a given metal for a given purpose) that takes place in the complete structure, the test-piece should be as large as is practicable.

(4) That such test-piece, together with the best method of testing and inspection, should be adopted as a standard by engineers and consumers.

(5) Without such standard and uniform methods of testing and inspection, the results of the work of the individual engineer, and the merits and safety of the structure he has designed and built, cannot be

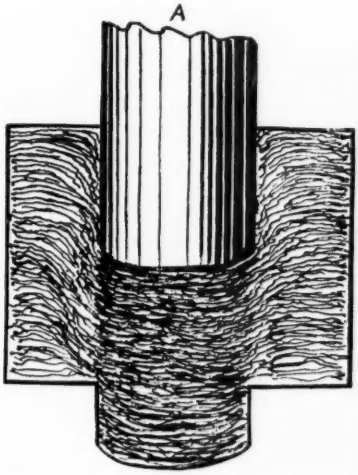


FIG. XI. FLOW OF METAL UNDER A PUNCH.

compared with those of other engineers, thus preventing interchange of ideas and experience, and hindering progress in engineering and in the manufacture of metals, besides increasing cost without benefit to the consumer.

(6) The properties of iron and steel are such that it is not necessary to prescribe an unvarying test-piece, and method of testing and inspection. But within certain narrow limits the same length, width, or diameter and shape should be used, as well as nearly uniform speed. In other words, there should be not only the largest amount of metal in the standard test-piece, but a practically uniform amount.

In conclusion, I would say that the attempt to graphically illustrate the flow of metal in a test-piece is not the result of imagination, or of a theory built upon elaborate deduction, but a record of observations of broken test-pieces that were highly polished. On slow pulling, the structure and arrangement of the particles during flow become plainly visible to the unaided eye. In fact, in some instances the shearlines and possible inequalities in the metal are so pronounced that a man can feel them. The concluding illustrations, taken, in three cases, directly from planed and etched metal sections, show how the plasticity of iron and steel helps, under favorable circumstances, to strengthen the members of a structure and, through this, the structure itself. In Fig. XI we have an exhibition of the well-known fact that the amount of metal punched out of a nut or plate is never as much as the amount of metal necessary to fill the hole punched, for the reason that, as the punch A advances, part of the metal escapes, or flows, from under the punch sideways into the body of the nut or plate, due to its plasticity. In Fig. XII we have a bolt which is materially strengthened by the fibers of the iron adapting themselves to the curvature of the outlines of the bolts. This tendency

FIG. XII. A BOLT HEAD.

to strengthening is still better seen in Fig. XIII, which shows how the metal of the rivet flows into every crevice and grips the two plates as if in a vise.

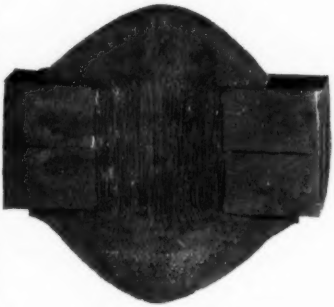


FIG. XIII. SECTION OF A RIVET.

Fig. XIV, is a U rail, such as were used in this country on our railroads some fifty years ago and later, as may possibly be remembered by some of the older readers of this magazine. We see again how the fibers of the iron adjusted themselves into the most favorable positions to add strength to the rail.

Thus, a study of the plasticity of iron and steel explains to the

FIG. XIV. SECTION OF A U RAIL.

patient inquirer some of the perplexities which confront the engineer in his daily practice.

THE GOLD-FIELDS OF THE PORCE RIVER, COLOMBIA.

By J. D. Garrison.

THE writer of this paper was employed during the surveys for the so-called Intercontinental (Pan-American) Railway, through Central and South America, as principal assistant to the chief engineer of the surveys, and was assigned to duty with Corps No. 2, which operated between Quito in Ecuador and San José in Costa Rica. During the progress of the work on the line through the State of Antioquia, in the republic of Colombia, his attention was called, at various times, to the great mineral wealth of that State, and particularly to the gold mines of the Porce valley.

His opportunity for examining these mines at length, while engaged on the surveys, was necessarily limited, and consequently he was unable at the time to give the matter a full investigation. He saw enough, however, to convince him that some of the mines observed were of extraordinary richness, and, since the completion of the surveys, above referred to, he has made a careful examination of these and other mines in Colombia. He has just returned from Antioquia, where he has been examining a number of properties purchased by an American company in the valley of the Porce, and his investigations have disclosed results so startling that it has been thought advisable to make them public. The writer deems it proper to state, however, that, in making them public, he is not actuated by advertising motives, but merely by a desire to make known, especially in the States, what seems to him to be information of great value to the mining world.

The republic of Colombia has long been known to the Spaniards and their descendants as being exceedingly rich in its deposits of gold, but, owing to its geographical location and its climatic conditions, it was only during the past few years that it began to attract the attention of the world at large.

Recent investigation in the country, on the part of foreigners, has disclosed the fact that almost untold wealth lies hidden in its mountain chains and valley streams, and a movement has lately been begun that promises to result in inaugurating in the country a mining "boom" that will rival those that have been seen in Australia and the Transvaal.

The old Spaniard, who was a wonderful seeker after gold, knew

the value of the Colombian mines, and he drew largely from them in gathering the wealth that went to enrich the "mother country" during the palmy days following the conquest of the southern hemisphere. His descendants, too, have profited by his knowledge, and have followed in his footsteps in taking from the bountiful stores that nature has lavishly placed at hand; and, in almost every section of the republic, they have continued to operate mines that, since the emancipation from Spain, have yielded, without machinery, a steady stream of the "yellow metal" which has swelled the output of the country to more than $700,000,000.

Nearly every State and province in Colombia has its gold deposits, more or less rich, and from some of these deposits have come, at times, yields that almost challenge belief. The stories that have come to the outside world, from time to time, of the gold alluvions of the Darien, Choco, Atrato, San Juan, Cauca, Nechi, and Porce, and the rumors set afloat regarding the fabulous richness of these fields and streams, have read for half a century like fairy tales. Yet many of these stories have a basis of truth. Explorations, in recent years, into the regions mentioned have brought to light the fact that, within their precincts, in some places, lie stores of wealth of vast extent, though formidably guarded against the encroachment of man by climatic and other conditions too deadly to face.

The State of Antioquia, though but little known, by reason of its almost inaccessible location, is perhaps the richest State, in mineral wealth, in all Colombia. Situated, it might be said, almost in the "lap of the Andes," and cross seamed by many spurs from the parent chain, the State presents an almost unbroken area laced with gold-

BOLIVAR PARK, MEDELLIN, COLOMBIA.

GENERAL VIEW OF MEDELLIN, SITUATED ON THE UPPER PORCE.

bearing quartz veins of great value, while many of its streams have valley deposits of placer gold of almost incredible richness. Nearly $150,000,000 in gold have been taken out of the mines of this State during the present century, although most of the workings there have generally been limited to surface deposits easy to reach. A very large proportion of this amount has been taken from placer deposits in the valley of the Porce, a river that has long been known to be exceedingly rich in gold.

This river, which seems to be of comparatively recent origin, has its source in the heart of Antioquia, near the city of Medellin, and drains northwardly, between the two ranges of the Cordilleras, through a distance of about 175 miles, to its junction with the Nechi. Through a good portion of this length it is fed by mountain streams and torrents that have cut their way, in deep cañons, across the flanks of the Cordilleras, and that bring into the valley, with their detritus, gold from innumerable veins. As a consequence, the river has, for over sixty-five miles, an almost uninterrupted series of gravel bars, or flats, exceedingly rich in gold. So rich, indeed, are some of these bars that much speculation has been indulged in relative to the source of their supply.

The usually-accepted theory is that it comes from the mountain veins uncovered and cut by the torrents above referred to. An-

THE PORCE RIVER IN THE SUBURBS OF MEDELLIN.

other, and more prolific, source drawn upon appears to have been generally overlooked. From the topographical features of the country, and the geological formations exposed, it seems that, prior to the existence of the Porce, the drainage of this part of the continent was effected through an immense river, now extinct, which had its course almost parallel with the present direction of the Porce. This ancient river was evidently destroyed by volcanic action, and its bed, which was rich with the accumulated gold of ages, was thrown up and inclined against the mountain flanks. The Porce, afterwards breaking through the disturbed territory, and having feeders that cross and wash the inclined channel of the old river, has ever since been drawing from that immense source vast amounts of placer gold that, combined with the products of the quartz veins adjacent, have made up the richness of the valley bars.

Mining has been carried on in the valley to a greater or less extent for over three hundred years. The Indians inhabiting this portion of the continent washed out gold in a crude way, and they, of all the tribes in Colombia, had most gold to sell to the Spaniards. They frequently gave the "conquerors" twenty dollars in gold-dust for a pound of salt, and seventy dollars for a hatchet, and it is said that in one of their villages the Spaniards found more than $20,000 in gold. The Spaniards mined in the valley for many years with

good results, and, following them, the natives also. From 1602 to 1620 more than $6,000,000 were washed out here, and, although working has been limited almost exclusively to superficial deposits, easy to mine, the output has steadily increased, until, in recent years, it has been estimated to run more than $1,000,000 annually.

Individual instances of great returns for working are on record. On the lower reach of the river the natives have taken out, by diving, pans of gravel that yielded more than two pounds of gold. One proprietor, after spending nearly $75,000 for the introduction of water, washed out, in a few days, more than 10,600 ounces of gold dust, and from a small bar in the river valley, though hardly 500 feet long by 50 feet wide, more than $200,000 were taken. At the Cristina mine, some years since, fourteen men, in thirty hours' work, washed out 118 ounces of gold, while at Barcinos 265 ounces were extracted from about 160 cubic yards of gravel. At Guayabalito the daily yield in the winter (dry) season, with a small force of men, runs from 44 to 102 ounces; at La Llave it has run from 26¼ to 29½ ounces; at Caracoli, from 58 to 73½; at Naranjal, 15; at Oralito, 73½; and, at Socorro Megaron, as much as 132. At San Basilio, in two weeks' work, 764 ounces of gold were taken out in the winter of 1886, and at San José 588 ounces were extracted in the working-season of 1885.

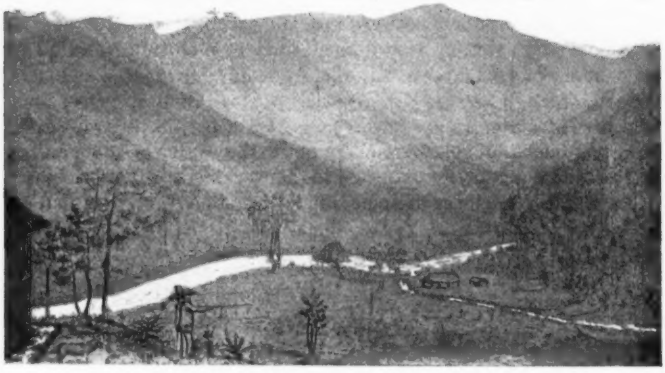
An English engineer of some repute examined and reported on

THE PORCE RIVER, NEAR MEDELLIN.

the richness of the Porce river some years since ; he estimated that the river contained gold in the proportion of $14\frac{7}{10}$ ounces per superficial square yard, and that in the lower fifty-mile reach of the river, after its junction with the Nechi, there were more than 4,000 tons of gold !

The writer of this paper noticed, during his connection with the surveys of the Intercontinental Railway, the richness of some of the Porce bars, and he has recently been conducting some examinations and tests which show results in keeping with those above described.

At one place, where the bar had a formation of about six feet of loose sand (decomposed granite) mixed with boulders, and below this another formation of gravel, sand, and boulders, the upper stratum showed, from the "grass roots" down, an average of $6 per



A PART OF THE PORCE WHERE BARS ARE FORMED.

cubic yard, while the lower stratum gave an average of more than $80 per cubic yard. At another place three cubic feet of gravel, taken as average from fifty different places in the lower stratum, yielded $15\frac{81}{100}$ grams of gold dust, or about $9 in gold ; there being $31\frac{1}{10}$ grams in 1 oz. Troy, which is valued, in this gold, at about $18.

At still another place, from 256 pounds of gravel, taken from sixteen different places, $6\frac{4}{10}$ castellanos of gold dust were washed out. This result corresponds to a yield of nearly $200 per cubic yard, the specific gravity of the gravel being about 2 and the weight of a cubic foot about 125 pounds. The former result corresponds to a yield of about $80 per cubic yard. Several wheelbarrows of gravel (three or four cubic yards), at another place, gave $435. One batea yielded $7.50 in gold dust, and, out of several hundred bateas taken, not one

failed to show gold in immense paying quantities. Other tests were made with results equally startling, but those given serve to show the enormous richness of the river valley.

When one remembers that, according to Silliman, Cumenge, and Lock, the rich gravel along the Yuba river, and at "Pond's Claim," in California, averaged only from 34 to 45 cents per cubic yard, while the gravel at such mines as Independence, Todd's Valley, Roach Hill, and Iowa Hill ran only from 25 cents to 71 cents per cubic yard, he can begin in some measure to appreciate the enormity of these figures. The writer is constrained to admit that they read like a fairy tale, and, had not the richness of the river valley been fully demonstrated by the examinations of experts and by mining opera-

THE PORCE IN A REACH WHERE NO BARS HAVE FORMED.

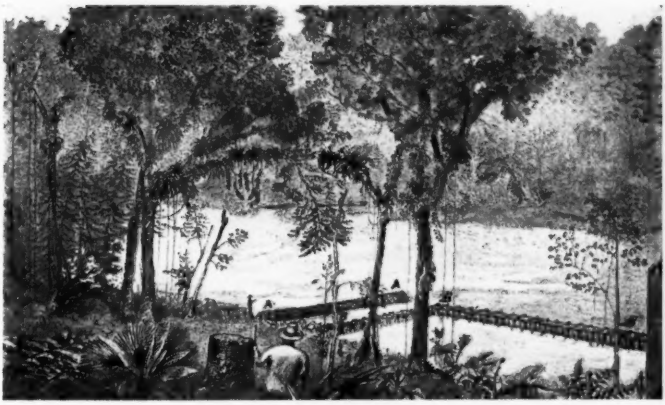
tions, he would certainly hesitate to give them. Of course, places have been found in California, and elsewhere, where the yield of gold was greater even than the figures given above. These places were known as "pockets," however, and were limited in extent, whereas almost the entire valley of the Porce seems to show the large average given; demonstrating the fact that, through exceptionally favorable conditions, the river has been, for many years, the reservoir for gold deposits from almost unlimited fields.

The question will naturally be asked: Why, if this river is so rich, has it not been mined out already? As before stated, mining operations have been carried on in the valley by the natives, and by the Indians before them, for more than three hundred years. They have been limited, however, almost exclusively to the deposits that were in-

clined against the hillsides, where bedrock was above the level of the river, and to the old channels that were easy to work. These deposits have been practically exhausted. The rich deposits, however, that lie below the level of the river, and that require expensive machinery to work them, are almost intact, and they have never been worked, except by the primitive method of "Veraneos," common in the country, which consists in sinking, in the dry season, to bed-rock, a rude caisson, composed of sticks, earth, and vines, and working the gravel thereby uncovered. No regularly organized scheme of mining these deposits has ever been carried out, and for obvious reasons.

Antioquia being situated far inland, and difficult of access by reason of the lofty Cordilleras on the east, south, and west, and the almost impenetrable jungles and morasses of the Atrato, Cauca, and Magdalena on the north, is almost unknown to foreigners, and even to the natives living on the coast. As a consequence, its mineral wealth has never been made known to the world, to attract miners, except through vague rumors that have come from an occasional wanderer who has found his way into the State by chance. And, when a foreigner, attracted by these rumors, has started to investigate them, he has usually become so appalled by the formidable obstacles presented by nature in his path, that he has generally turned aside to investigate fields in nearer provinces, report of which has reached his ear. The entire republic of Colombia is so rich in mineral wealth that the seeker after mines there generally becomes bewildered, as soon as he has entered the country, by reports coming to him, from almost every source, of mines fabulously rich that deserve his attention. As a re-

"VERANEO." CLEARING THE GROUND PREPARATORY TO BUILDING A CAISSON.



A CAISSON ABOUT COMPLETED.

sult, in face of the obstacles intervening between Antioquia and the coast, he generally turns aside to other and nearer fields. The writer knows personally of several expeditions that left the States for Antioquia, and were thus diverted. In view of these facts, very few foreigners have ever penetrated to the rich mines of the State, and those that have penetrated there have usually been unable to provide the capital necessary for working mines. The natives of Antioquia are not, as a rule, mining people, and those that have means sufficient to develop a mine are generally merchants who have made their money in trade, and who are unwilling to risk it in the more hazardous business of mining. There are only a few persons in all Antioquia having as much capital as $200,000 in gold, and they know absolutely nothing of forming large stock companies, such as we have in the States. Furthermore, those that have money live in the cities on the upper table-lands, where the climate is healthy, and they are unwilling, except when necessity compels, to venture into the lower and more unhealthy mining regions of the river valleys. In consequence of this, it is only those, generally, who have to become ruined or crippled in trade that undertake mining operations to recoup their fortunes; and it almost invariably happens, with these, that, as soon as they have amassed wealth enough to return to merchandising,—no matter how fabulously rich their mine or large its returns,—they either abandon the work to a foreman, or lease the mine to some one they wish to befriend.

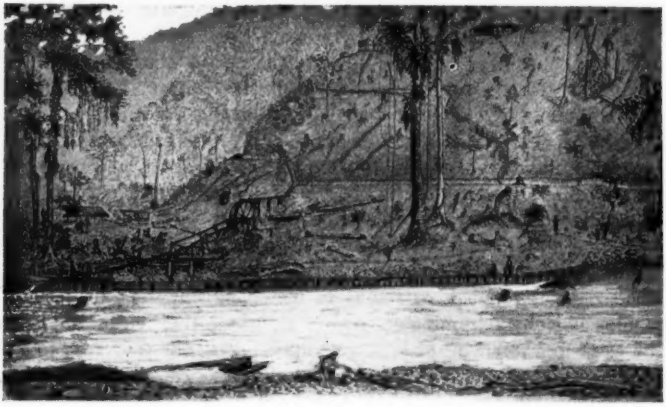
The climate, too, which is bad in the river valleys, and everywhere except on the elevated table-lands, and the highways, which are almost

WATER WHEEL AND PUMP AT ONE OF THE MINES.

impassable for machinery, have helped to throw obstacles in the way of mining on any extended scale.

All of these things have combined to prevent in Antioquia, and even in Colombia, a mining "boom" that would have led to the working of the alluvial deposits of the Porce. That such a "boom" will soon occur, however, is easy to be seen. The rich discoveries of silver which enriched Chili were made from 1825 to 1848; the gold alluvions of California were discovered in 1848; those of British Columbia in 1858; the rich silver mines in Nevada, which have lowered the price of silver, were discovered in1859; those of Bolivia in 1860; the rich gold deposits of Guiana and Venezuela in 1866; and those of the Transvaal within recent years. Impelled by recent financial agitation in the States and elsewhere, the world is now "casting about," in every direction, for new gold fields, and Colombia's day appears, therefore, to be near at hand.

When that day shall have come, and, the present primitive appliances and methods being discarded, improved machinery and recently-discovered methods of mining shall have been applied to the working



PUMPING WATER FROM THE SPACE WITHIN THE CAISSON.

of the Porce and other Colombian streams, and to uncovering and extracting the gold from the vast lodes of quartz that are now lying hidden in Antioquia and other parts of Colombia, it is no hazardous venture to say that the world will view the results with unbounded amazement.

In order to prevent a misconception of the situation, it is eminently proper, before closing this paper, to warn persons against going to Colombia to mine without reasonable means. While the mining laws of the country are exceedingly liberal to both natives and foreigners, and while there are many rich mines to be discovered and claimed in nearly every section, it is still true that in Colombia, perhaps more than in any other country in the world, money is needed, especially for mining.

As for the valley of the Porce, there is probably, in all this territory, not a yard of soil that is not already taken, and nearly all of the river bars of any value are owned or controlled by a wealthy firm of native mine-owners, who do not care to sell them except for prices commensurate with their value.

SIX EXAMPLES OF SUCCESSFUL SHOP MANAGEMENT.

V.

By Henry Roland.

WHILE the contract system of labor-hiring may not now retain its place, in the estimation of authorities, as a thoroughly successful one, it nevertheless has played too large a part, and is still too widely used, to be omitted from the scheme of these articles.

It may well be that concerns operating under this plan are incurring a disadvantage in one direction which they can offset only by peculiar facilities in some other, as by the command of peculiarly favorable markets or unusually liberal profits. But the system marks a distinct step in the advance to a still better one.

It is yet in use in nearly all rolling-mills, and in many large and important machine-shops, but, though once believed the best possible for the production of good work at low cost-price, is now falling into disfavor, and by no means furnishes a guarantee against strikes and disagreements between employers and the employed.

I shall not treat the rolling-mill system with particularity. As is well known, this system embodies a "scale," or ton-prices for finished rolling-mill product agreed upon by the rolling-mill owners and the Amalgamated Societies of Steel and Iron-workers to hold for one year from date. After this price is once decided for the year, there is no trouble, but the agreement is often preceded by a time of stormy disagreement between mill-owners and mill-workers. In the usual form of "scale" working each boss roller hires, pays, and discharges his own gang of men, the head roller contracting directly with the owners, who pay into his hands the whole price of the work finished by him and his subordinates. As is the case with all contract systems, the pay of the contractor or head roller is very large in comparison with that of his assistants, and, in the light of the results of the contract system in other lines of metal-working industry, it seems probable that other methods can produce equally good results at less cost to the management and with less probability of trouble from conflicting interests. The use of the "scale" and the contract system is, however, at this time universal in rolling mills, and there is no present sign of immediate change in labor-employment methods in concerns of that class. It is probable, however, that the same general laws govern the contract system in rolling mills that have been

found to dominate that system when used in machine shops and small-arms and sewing-machine factories, where the contract system was at one time regarded as possessing advantages not otherwise to be had, but where it has now fallen into disfavor, and either has been, or is likely soon to be, displaced by fixed-pay foremen in charge of piece-rate workmen.

Among the establishments still using the contract system are to be found many of the New England machine shops and armories,—the Pratt & Whitney Shops, employing about twelve hundred men, and Colt's Armory being among the more important examples. The Pratt & Whitney Shops, while still largely using the contract system, also work a great number of men at day wages, and the contract system is not regarded with favor by the management, although its use insures a constant reduction in cost-price of work, and special incidents frequently emphasize the advantages of the contract system in a manner to enforce attention. Thus, in case of an order for some half-dozen machines which could not be undertaken by the contractor who usually built them, as his department was full, the order was given to another department filled with workmen of a slightly higher grade than that of those employed by the contractor to whose department the job ordinarily would have gone, with the result of 70 per cent. increase in cost over the contractor's rate, while the work was not up to the contractor's standard. Here were better mechanics, taking them at a machine-shop estimate, and in a high-grade shop with the best facilities procurable, thoroughly experienced in the special line to which the lot of machines demanded belong ; and yet these good men in this good shop produced inferior work at a very greatly increased cost-price. It was such instances as these which gave the contract system its prestige, and kept it in force for many years, in spite of the certain features inseparable from the system and extremely unpleasant to managers.

First of all, the contractor is and must be supreme in his department ; he must fix the wages of his men, must have absolute control of them, must hire and discharge his help at will, and so becomes in effect an independent ruler in the territory of the management. If, as is the case in some shops, the management deals solely with the contractor, and delivers into his hands the savings of his department in a lump sum, the contractor paying his own men, then the management is wholly ignorant as to the compensation obtained by the contractor himself and of the cost of the work to the contractor, who keeps his own books, and is, in every sense of the word, an independent power, and a power which must obviously be treated as an equal, although actually occupying the anomalous position of a belligerent

inferior. The interests of the contractor are directly opposed to those of the management, and the yearly "adjustment" of prices, always involving a reduction of the contractor's prices, is a constant source of perplexity and dissatisfaction to both parties. The management sees the contractor, in spite of the yearly cut in prices, constantly drawing larger pay than he could obtain as a foreman, because he seems always able to improve his methods so as to reduce the cost of his product to himself; hence the management believes that the contractor holds his improvements in reserve, and is, in effect, depriving the concern of the use of valuable methods of reducing cost known to himself alone, and kept back to neutralize the effect of future reductions in prices. The contractor is not unmindful of his own efforts in reducing the cost of work, which he rightly believes to have resulted greatly to the benefit of the management, and to justly entitle him to a portion of the increased profits arising from diminutions of cost effected by his skill and ingenuity. Hence the contractor, like the piece-work man whose piece-price is constantly reduced, finally ceases to exert himself, and makes his own gains so small as to ensure himself against reduction. It is very clear, therefore, that the contract system does not tend to develop ideal conditions of harmonious relation between the contractor and the management, and that, while strikes may be rare under a contract system, there is still a feeling of antagonism, growing out of opposing interests, which is unfavorable to the best results. The management does not wish the contractor to cease his efforts to reduce cost. It is, in fact, of vital interest to any and every machine-maker that quality be constantly improved, while cost is at the same time reduced. The shop which stands still goes backward, because of the advances made by rivals, and this condition of affairs points clearly to the substitution of the well-paid department foreman superintending piece-workers, in place of the contractor, paid at an unknown rate, with his force of day-workers. The contractor does not commonly pay his men piece-rates; in some cases contractors use sub-contractors, and in these this method was once largely in favor; at present, however, the contractor clearly recognizes the propriety of being himself the only high-pay man in his department, and makes his foreman and all other subordinates day-rate workers.

No more instructive example of the successive employment of day-rate, contract, and piece-rate workers can be found than that given by the labor management of the Singer Sewing Manufacturing Company, which has been in operation well towards fifty years, and has over 10,000 shop employees, all under the same management, precise information as to the policy of this establishment since 1863 being available. The Singer company had one strike

in the New York shops at the time the eight-hour day was legalized; the strike was for an eight-hour day with ten hours' pay, and entailed a shut-down for five weeks, at the end of which the men came back to the regular ten-hour day, which has held ever since. The Singer company had in 1863 about 700 men at their only shop, located in Mott street, New York city, had no milling machines and no gang drillers, and was doing its work on lathes and planers. The parts did not "gage" at all; assembling was very expensive; and, after a machine was adjusted and in sewing order, all of the parts were kept by themselves while the frame was being japanned, and afterwards put back on the same frame, as they were very far from interchangeable. The pay at that time was principally by the day. In 1863 the Singer company put in its first ten milling machines, made by the Manhattan Fire Arms Co., at its Newark shops, on a modified Lincoln pattern. Following the success of these machines, many others were immediately introduced, gang drills and screw machines were brought in, and the whole place was brought up rapidly to the armory plant standard. With these improved tools, necessitating skilled or specialized laborers, instead of machinists, contracting came in, and day-pay went out. The contract system, with day-pay operatives under the contractors, became general in 1866–7, and held its own about fifteen years, until 1883, when it was finally dropped in favor of fixed day pay foremen and piece-rate workmen, which system is now in exclusive use at both the Elizabethport and the Glasgow factories.

At first each contractor hired, paid, and discharged his own men; with them the company had no dealings whatever, exercising over them only general authority in the matter of shop-regulations. These contractors were entirely in control of the work. They received with the contract small tools enough to equip the machine tools in their own departments, but the use of these small tools was optional with them; each contractor kept up his own tools, and, if he desired improvements in the tools, made them himself with his own tool-makers, of which each contractor kept a larger or smaller force at his own expense. It will be seen that, with this order of things, the management could be kept in almost total ignorance of the real course of affairs in any contractor's department, and, in point of fact, was kept in ignorance so far as the contractors could avoid giving information. Contractor's rates were made to hold from January 1 to December 31, and were reduced to what the management guessed was about the actual cost to the contractor. The result of all this was that, while some of the very small contractors made as little as $2,000 per year, some of the larger ones, running two hundred or more men each, made more than $10,000 a year, and these earnings (in all cases vastly more

than they could have obtained elsewhere for their services) did not vary much from year to year in spite of the annual reduction in prices paid by the company. January 1 each contractor put his tool-makers at work and kept them busy until he saw the way clear to his usual earning for the twelve-month; then he confined his labors to thinking for the remainder of the unexpired contract time. This process was easier than at first sight it appears. With two hundred men a contractor had only to make each man turn out fifty dollars worth more work in the year than he produced the year before to make up his profit of $10,000, which the company found itself powerless to diminish. Say with two thousand workmen the contractors, great and small, might divide $100,000, or $125,000, among themselves, while at a day rate these same contractors could not have obtained more than $30,000 or $40,000, thus making the company pay a very large sum above what it believed the actual value of the contractor's services to be. This led very naturally to a close scrutiny of the situation, and resulted, first, in the payment of the contractor's men by the company directly. This looked like a very innocent and unimportant change, but it was really the thin end of the wedge which was ultimately to deprive the contractor of his profits. As soon as the company paid the workmen, it had correct information as to the piece-cost of the work, and could also, of course, discover which pieces were high and which low in price, in view of the labor-time consumed in production. Hence the company became able to approximate more closely to the contractor's possibilities of cost-reduction for the next year, and so could more intelligently "adjust" or reduce the prices offered in the annual contract. Yet this made little difference, on the whole, in the gains of the contractors. It was true that the price of work was annually reduced, and that the quality of the work steadily improved, but the company did not view the great gains of the contractors with any approach to satisfaction, and finally, about 1883, the whole contract system was abrogated, and the policy of fixed-pay foremen and piece-rate workers was substituted without the slightest difficulty, the old contractors, without exception, remaining as foremen, though under greatly reduced pay, even very generous foreman's wages being far below the great sums obtained yearly by the same men in their previous positions.

Some of the worst features of contracting, especially the sub-contractor extortion, had been previously eliminated. By the sub-contractor system the principal contractor became almost an idler, drawing a large sum of money for merely nominal service. The sub-contractors drew large pay and were directly interested in continuing the system, which virtually made the company pay two large profits

to its own workmen for its own work done in its own shop on its own tools, all paid with its own money. But the sub-contractor system was not very long endured after its full scope and purport became apparent. It is not obvious at first sight that the company could be a loser by the sub-contract system. It seems that, having agreed upon a certain price for a certain number of certain pieces of work, it had put the matter in final form, and that the sub-contractor was a matter of interest to the principal contractor only. But the sub-contractor extended the principle of efficiency brought into play by the contract system itself, which is the certainty that constant, minute, and highly-interested scouting directed upon any article of manufacture by specially-trained intelligence will always result in a reduction of cost. Hence the more contractors, the more minute the sub-divisions of the narrow field of observation, and the more improvements devised and retained until after the signing of the yearly contract for development, to bring the new year's profits under the reduced scale up to the previous year's standard. It is clearly seen in this light how the specious claims of the contract system to economy could remain so long unconfuted. The advocate of the contract system truthfully asserted that the constant close attention of the contractor made work cheaper than it would be made under the mere general observation of any superintendent, no matter how able, and that, since the high pay of the contractor was coupled with a low piece-rate to the company, the contractor's large profit was simply good money well paid to a good and profitable servant.

The true answer to the foregoing is fully given by the experience of the Singer Company, which is especially valuable because it has embraced a large number of operatives, and has extended over a long period, and hence is removed from the possibilities of special premises or developments which might cause results from smaller or less extended application of its methods to be regarded as but doubtfully conclusive.

This experience shows that, with fixed-pay foremen, the cost-reduction is fully as constant and rapid as it was under the contract system, and this saving comes sooner to the owners. Suppose a contractor, having already in view sufficient improvements to make his profit for a certain year, should in January devise a further improvement; he would then hold that until after the next contract was made, and it would be almost two years from the time the contractor knew of the possible gain before the owners begin to benefit by it. As things now are, as soon as an employee devises an improvement in manufacture, he brings it to the management and it can be used at once, instead of the owners having to wait for the knowledge of it until it

becomes needful to the foreman's interest to use it. Experience has shown that, with a wise and liberal policy pervading the establishment, and with a good system of accounts, the heads of departments will have sufficieht ambition to make a good showing, and so friendly a rivalry will exist between departments worked on the piece-work system as to effect a satisfactory economy, while preserving a better feeling among the employees than is secured by any other method.

The pay of the operatives under the piece-rate is better than it it was under the day-rate, and is not reduced by a reduction in rates resulting from improvement in methods or tools.

Whether the same causes which make the contract system unsatisfactory to the machine shops will finally result in banishing the "scale" and the "boss roller" system from the rolling mills or no cannot now be predicted. The laws of contract labor cannot vary in their results; yet it may be a long time before fixed-pay bosses and piece-paid workers come into the rolling-mills, and it may even be a long time before all the contractors disappear from the New England shops.

There are abundant anomalous conditions in actual labor employment in the United States, and the discrepancies may continue for a long time, although one of them, the high machine labor prices in the vicinity of Cleveland, Ohio, seems in a way to regulate itself, as it is reported that the Brush Electric will remove from Cleveland to Lynn, Mass., and that the Lozier cycle factory will go from Toledo to some point east of New York, to escape the exactions of thoroughly-organized labor, which make machine production more expensive in that region than elsewhere.

One thing seems certain, however,—the gradual extinction of the contract system and its replacement by fixed-pay foremen controlling piece-rate workmen.

MATERIALS AND METHODS IN FIRE-PROOF CONSTRUCTION.

By Wm. M. Scanlan.

THE educated architect of to-day is familiar with the strengths and characteristics of building materials as established by scientific investigation, and knows how to use these materials most economically. The improvements in modern building, together with the large reduction in cost per cubic foot of space, testify to the beneficial results of this knowledge. The fire loss, however, is still an enormous tax upon the wealth of the country, and the methods adopted to render buildings safe from destruction by fire are often unreliable, expensive, and troublesome. This state of affairs indicates that the problem of fire-proof construction has not been taken up for scientific consideration, and that architects have not the same facilities for acquiring information on this subject that they have as to other branches of the building trades. There is, however, a growing interest in the subject of fire-proofing, and a very general desire for a larger knowledge of fire-proofing materials and methods. It is significant that in a description of the great Manhattan Life Insurance Building in New York city, written by one of its architects, Mr. Francis H. Kimball, and published in THE ENGINEERING MAGAZINE, the only details which Mr. Kimball criticises, and in which he suggests improvements, are the fire-proof floors and partitions.

An architect, in designing a fire-proof building, usually proceeds to design the steel framing for the floors without waiting to decide what kind of fire-proof filling he will place between the beams. If, as is usually the case, his ceilings must be flat, he concludes that some kind of hollow flat arch will be used, and fixes the span of the arch at about five feet. Now, this arrangement is precisely that which was introduced in 1871 by Mr. George H. Johnson, the pioneer in the use of hollow tile in floor-construction, and, while the rolling mills have progressed with the times, substituting steel for iron and improving the shapes of sections, constantly reducing the cost of their part of the floor, most manufacturers of fire-proof arches have remained stationary for the last twenty-five years, and the generally-used form of hollow-tile flooring has shown no improvement in design or construction since its introduction.

The ideal arrangement of steel framework for ordinary office-buildings is one consisting entirely of columns and girders. The gir-

ders should be placed in line with the partitions, so that the ample non-conducting fire-proof covering with which the girders should be protected would appear in the room as a cornice. On these girders the fire-proof floor should rest, and it is entirely possible to construct self-supporting, non-thrusting fire-proof floors covering the area of an ordinary office that will render loose tiles and cracked ceilings impossible. It is generally admitted that, the less steel there is in the construction of an incombustible building, the more nearly fire-proof it is, and many instances are pointed out where the iron or steel in the floors or roofs hastened the destruction of the building by expanding and throwing out the walls, or by softening and sagging sufficiently to allow the floor arches to fall. In tall commercial buildings economy of space requires thin partitions and small columns; now, steel occupies less space than any other material that will carry the loads, and, when protected against fire, will cease to be an element of danger.

The simplest and most obvious way to protect steel from the action of heat is to surround it with a covering of some non-conducting substance, which will remain in place despite the action of fire and water, and which will not act injuriously on the steel where it comes in contact with it. A simple experiment on the kitchen stove will show which of the various substances now offered in the market as fire-proof building materials is the best non-conductor, and therefore the best material to use for preventing the heat of a fire from reaching a steel column or girder. Take flat pieces of dense tile, porous tile, cement concrete, and plaster of Paris, of the same thickness, and lay them side by side on top of a hot stove. Place on the center of each a piece of lead, and see which piece of metal remains unmelted the longest. It will be found that the lead on the dense tile will melt first, that on the portland cement next, and that on the plaster of Paris and porous tiling last. Plaster of Paris retains its moisture for so long a time after setting that it should be thoroughly dried at a moderate heat before the experiment; otherwise, it will remain at a temperature of 212° until all the water in it is evaporated.

To see how the different materials will stand the application of cold water while they are in a heated state, the different samples may be dropped into a pail of cold water as soon as removed from the stove; it will then be found that the plaster of Paris suffers more than the others, as fine cracks or checks will appear on its surface and it will lose nearly all its tensile strength. As a result of such experiments, it was found that porous tiling was the best material to use for protecting the columns and girders of a building from the action of fire; it is as good a non-conductor as any for the purpose, and is not injuriously affected by cold water applied while the tiling is hot.

It is clear from the foregoing that the heat of a fire in a building can be kept from the structural steel by surrounding the columns, girders, and beams with porous tiling; the thickness required depends entirely upon the intensity of the heat and the duration of the fire. As much protection can be given as the owner is willing to pay for, in money and space. The question of thickness of covering is a point commonly overlooked, and we find buildings containing great masses of combustible merchandise constructed with no more precautions against fire than are commonly taken in an office-building with very little combustible contents.

Connected with the question of floor framing and columns is the question of weight of floor, and this leads us to the consideration of the prevalent custom of piling up dead weight on top of the arches, in the form of concrete filling. There is no reason why the tile arches should not extend to the top of the steel beams. This may increase the cost of the tile, but it will save not only the cost of the concrete, but also the time required for putting it in place and drying it out, besides keeping out of the building a vast amount of water that has all to be evaporated before the building is dry. Again, the deeper arch will be lighter, stronger, and stiffer than the shallow arch and concrete.

In some cases, and especially in New York city, it has been customary to use tile arches merely as a fire stop between stories, the floor boards being carried on wooden joists reaching from beam to beam and a hollow space being left between the top of the arch and the bottom of the joists. This method saves the use of concrete, but it does not deserve the name of fire-proofing, as the floor is carried on wooden joists and a hollow space is left by which the fire can communicate from one joist to another, besides which the wooden joists and flooring are placed directly upon the unprotected upper half of the steel floor beams. A construction similar to this was practically tested, with disastrous results, in the Manhattan Bank Building fire in New York.

An architect, having designed the floor framing plan of the building, is ready to consider bids for the fire-proofing, and here he is confronted by a large number of different varieties of fire-proofing and forms of construction, each claimed by its manufacturers to be the best. Each system of fire-proofing worthy the name uses either dense tile, porous tile, cement concrete, or plaster of Paris as its principal material. If it were necessary, we could experiment to determine which forms the best flooring for resisting the action of fire and water, and for carrying loads. With regard to two of the materials we are certainly saved this trouble. The exhaustive tests of floor arches made at Denver, Colo., under the supervision of Messrs. Andrews, Jaques & Rantoul, architects, of Boston, which the writer personally witnessed,

have settled the question beyond a doubt as between dense tile and porous tile—or porous terra cotta, as it is sometimes called.

It does not speak well for the progressiveness of our architects that these tests, which were exceedingly thorough and exhaustive, and the results of which, though published in a widely-circulated architectural journal*, have never been questioned, should have had so little effect on the construction of later fire-proof buildings. The material and form of construction that were proven vastly inferior are still largely used by some of our leading architects. The manufacturers of fire-proof tiling are more to blame for this than the architects, as, instead of producing the better material only, they continue to turn out the inferior dense tile. Properly made and burned, there is no safer or more substantial material entering into the construction of a building than porous tiling, and, from the manufacturers' standpoint, porous tiling, when its manufacture is understood, is more easily, more cheaply, and more rapidly produced than dense tiling. Mental inertia, however, tends to keep manufacturers from adopting new materials and methods as long as there is a market for old wares.

Briefly stated, the tests of fire-proof materials at Denver proved that dense tile is unfit for the purpose of fire-proof construction, because it is too brittle, breaking at the first blow like a sheet of glass, and because it does not stand the action of fire, or of fire and water, in each case acting very much like glass. The tests further showed that the dense tile "side method" arch was greatly inferior in weight-bearing capacity to the porous terra cotta "end construction" arch. The condemnation of the dense tile arches by these tests is rendered more emphatic by the fact that two separate sets of arches of this kind were tested, each set made and erected by a different manufacturer, the results in the two cases being almost identical. These tests showed, on the other hand, that porous tile end construction arches could hardly be improved upon in strength to carry a dead load, or in ability to withstand shocks or blows, or in resistance to the action of fire, or of fire and water. After twenty-four hours of continuous fire under one arch, and of fire alternating with a stream of water under another, the porous tile arches carried as much weight and stood as many blows as did the two arches which had not been subjected to the fire tests.

That the results of these Denver tests are borne out in practice is testified to by Mr. Chas. H. Bebb, who, in a description of the fire in the Chicago Athletic Club, in THE ENGINEERING MAGAZINE, says: "While the results obtained (in the Denver tests) may have been considered problematical, this recent fire has been a practical test of their

* *American Architect*, March 28, 1891.

accuracy beyond question.... In its structural entirety the Athletic Club Building remained intact. The tile arches of porous terra cotta, set according to the very latest adoption in construction,—*viz.*, end construction,—are practically uninjured by the combined action of intense heat and tons of cold water; not an arch has fallen, and recent tests made on the worst-looking arches developed a sustaining capacity of four hundred and fifty pounds per square foot, without sign of rupture."

Dense fire-clay tile was the pioneer in the field, and served a good purpose in supplanting the heavy brick arch, but it has done its work, and must give place to a better material.

Let us next consider cement concrete as a structural material for fire-proofing purposes. When once in place, of good composition, well manipulated, and thoroughly dried out, it answers the purpose of a fire-proof floor well, and, under these circumstances, there is but one objection to it—its excessive weight. The practical objections to it, developed as the work of building progresses, are the watchfulness and care required to insure that proper materials in the proper proportions are used in its composition, and that the mixing and ramming into place are properly done. Another objection to it is the large amount of water used in its mixing, which should all be dried out before the wood finish is brought into the building; this involves delay, and in large buildings the loss of revenue caused by even a few days' delay is a large item. Some idea of the annoyance caused by the presence of moisture in a large building may be gained by reading Mr. Kimball's article. Cement concrete is manufactured at the building day by day, while the clay blocks are brought to the building ready made, so that proper inspection and rejection of poor material and work are more difficult in the case of concrete than in the case of porous tile. It is much easier to insure the use of good mortar and good joints between the clay blocks than to secure uniformly good work in the great mass of concrete to be used. Concrete is heavier, no stronger, no cheaper, less reliable, and has no better fire-resisting qualities than porous tile, and porous tile is a better non-conductor of heat.

The advantage that concrete has enjoyed over hollow-tile for flooring was that it could be used with iron tension rods and carried to greater spans, without thrust, than is possible with the ordinary flat arch. But, since the introduction of steel tension-rods in combination with porous tile blocks, the concrete has not even this advantage, and there are several reasons, stated above, for choosing porous tile in preference to concrete.

There remains now only one material to be considered—plaster of Paris and other forms of gypsum. This is usually mixed with shav-

ings, chips, etc., and used in connection with suspension cables stretching from beam to beam. All the objections (excepting that as to weight) applying to cement concrete apply with equal force to plaster of Paris. As this substance sets so very quickly, it requires skill and quickness to get it into position before it sets. In setting it hardens at the surface before it does at the inside, and this sometimes causes the surface of the ceiling to tear away from the mass. But probably the most annoying feature of the use of gypsum is the extremely long time during which it retains moisture. In the process of mixing with wood shavings, these shavings become saturated with water, and, when the mass is put in place, the gypsum sets at the surface first, rendering it difficult for the water to escape from the interior. Of course this moisture does escape after a while, and naturally, by descending through the ceiling, to the destruction of the tinting or the decorations that may have been placed thereon. Again, gypsum has a destructive corroding effect on iron and steel in contact with it; the suspension cables and rods connected with it are usually galvanized, but the steel beams are protected merely by the usual coat of paint. Again, the shavings and chips buried in the plaster of Paris are certain to be disintegrated by the action of dry rot, and in the course of time, when the shavings and chips have rotted, nothing will remain but a honeycombed mass of plaster of Paris, through which the suspension cables can readily cut. Like cement concrete, plaster of Paris has no advantage over porous tiling as a fire-proof material, except its light weight, and it is inferior in important particulars.

Of the four materials there seems, therefore, to be no reason why porous tiling should not be chosen as the best—in fact, the only unobjectionable fire-proof building material.

Porous tiling is made from plastic clays by mixing with the clay from fifty to sixty per cent. of sawdust, by bulk, and then, after thoroughly drying the material, burning it in a down-draft kiln. When the heat in the kiln becomes great enough, the sawdust in the mass of clay ignites and is consumed, thus helping to burn the clay all through evenly, and also leaving little cavities or cells in it. This cellular clay is known as porous tiling. It is much lighter than dense tile, but it has a toughness and resilience that render it much more reliable.

A point that is not generally considered is that, for the purpose of a floor arch in the form of hollow tiles, an excessive crushing strength in the material is a disadvantage, for the reason that, the denser and harder the material, the more brittle it is. We need crushing strength to withstand, with a reasonable factor of safety, the strain developed by the load carried, but, beyond this, increased crushing strength is uselessly attained at the expense of the very essential quality of toughness.

There are two general methods of arrangement of arch blocks in fire-proof floors, known respectively as the side method and the end method. The latter was first used for floor construction by Thomas A. Lee, in 1886. While other manufacturers have varied the shapes of the end construction blocks, the original square block of porous tile remains the simplest and easiest form to manufacture and to build, and gives the best results. (See Figs. 1 and 2.) The side method is the older, and is used generally by the manufacturers of dense tile arches; with dense tile it should speedily pass out of use, as poorly adapted to its purpose. (See Fig. 3.) In the side method arch the hollows in the tile run parallel with the supporting beams, and the disposition of the material in the arch is not at all in accordance with proper methods of design, inasmuch as the line of pressure of the arch has no solid material through which to act, and the abutment blocks are poorly adapted to withstand a shearing strain. Hence arches built after the side method, when weighted to destruction, invariably fail at the abutments under a load that does not develop a compressive strain of more than a small fraction of the compressive strength of the material.

In the end construction arch the disposition of the material is such that there is little or no waste material. All the vertical ribs are continuous, and extend from beam to beam, so that the curve of pressure of the arch acts through solid material throughout its whole length. The top and middle webs aid in taking the end pressure at the middle of the span, and the only part of the arch that is not in compression—*viz.*, the bottom of the shell—furnishes the level surface for the ceiling plastering. This construction is analogous to a series of incombustible joists extending from beam to beam, and having fastened to them incombustible boards, at top and bottom.

Whether the arch be built on the side method or the end method, the objectionable feature of end thrust is still there, ever tending to spread further apart the supporting beams, necessitating thorough tieing together of the beams, and causing most of the cracks that appear in the ceilings of the fire-proof buildings. I-beams are not designed to stand a lateral strain, and the thrust of the arches must be neutralized by efficient tie-rods close to the bottoms of the beams.

It is clear that, if sufficient tensile strength should be supplied near the bottom of an end construction arch, the structure would become a beam, and would act as a beam under all conditions. The top would be in compression, and the bottom in tension, when the structure was supported at the ends, and there would be no more thrust to be considered than in the case of a wooden joist. The desirability of extending the end construction arch to spans of any length, and the necessity of making the structure a beam rather than an arch, in order

to abolish the thrust, has led to the invention known as the porous tile beam-floor. This is an extension of the end method arch idea, and, to supply the needed tensile strength, there are supplied near the bottoms of the tiles steel tension-rods, composed of two strands, embedded in strong portland cement in the joints between the courses of tiles.

When the beam-floor is supported at the ends of the spans, the tendency to deflect produces compression at the top, and tension at the bottom, of the beam. The material in the porous tile is well adapted to stand a compressive strain, its ultimate crushing strength being 1,200 to 1,400 pounds per square inch; and it is necessary to supply only enough steel in the tension-rod at the bottom of the tile, in order to furnish tensile strength to balance the compressive strength at the upper part of the blocks. As cold-drawn steel wire has a tensile strength of 110,000 to 180,000 pounds per square inch, very little steel is required. No extension of the bottom of the structure under the action of a load is possible without stretching the steel tension-rods. As the thickness of tiling under the rods may be made as great as necessary, the structure can be made absolutely fire-proof.

The beam-floor, whether of porous tile or concrete, is unquestionably better than any form of arch construction. With the arch, it is impracticable to use long spans and retain level ceilings, and, where, as is usually the case, floor beams are provided, spaced from four to six feet apart, all of these beams may be saved by using a fire-proof beam-floor, extending from bearing to bearing; the substitution will give a stronger, stiffer, and lighter fire-proof floor at a decreased cost. As to the choice between concrete and porous tile beam-floors, the advantages and disadvantages of the two materials have already been discussed in this article. The porous tile beam-floor, by the thorough tieing together of all tiles in the floor, overcomes some very serious defects in the arch floor. It overcomes the cracking of the ceilings due to the deflection of isolated I-beams carrying arches; it removes the danger of whole arches falling out of the I-beams, when, from any cause, the beams have spread, or (most probably the initial cause of the Ireland Building disaster) when the rain has softened or washed out the fresh mortar of the joints of the arches.

The writer feels that there is much room for development in the field of fire-proof construction, and he has been intentionally explicit in naming those forms of construction that seem to him the best, in the hope that, if he is wrong, his errors may be pointed out. That the subject is worthy of the attention of all is evident when we consider that the past and present methods of building are costing the United States an annual fire tax of one hundred and fifty millions of dollars, as well as the loss of many lives.

REVIEW OF THE ENGINEERING PRESS

The Nicaragua Canal Company's Methods.

THE RAILROAD GAZETTE (Jan. 29) makes a severe criticism on the present methods and attitude of the Nicaragua Canal Company. The company has really no longer any standing in Nicaragua, and now would be glad "to unload a forfeited concession upon the United States government, and leave that government under the necessity of using the 'resources of civilization' against little Nicaragua, or lose its investment." Our contemporary says: "The obstinate opposition made by the officers of the Nicaragua Canal Company to every proposition to have more complete surveys and studies made before the nation should become responsible for the money to carry on the work has long been something of a mystery. It is hard to see why a course should be taken which was obviously delaying the settlement of the question, if the canal company really felt as secure in its position as it pretended to feel. The most extraordinary reason for haste which has been brought forward is that given by Mr. Miller, who urged that a waiting world should be relieved from doubt, and that capitalists at home and abroad feared to put their money into the project, lest the United States government should guarantee the bonds, and thus relieve the investor, not only of risk, but of the chance for a speculative profit. We suppose that even school-boys saw through the flimsiness of this argument." Evidence that the concession has been forfeited is referred to in a recently-printed letter addressed January 15, to the secretary of State by Senor Rodriguez, the minister of the Greater Republic of Central America. He declares that the five bills before congress relating to this canal "all take it for granted that the government of the United States is to take an important part in the enterprise and to furnish the money for construction," and that "the provisions of each are at variance with the stipulations of the contract of April 24, 1887, between Nicaragua and the company, from which contract the company derives its existence." It is expressly stipulated in this contract that the concession shall not be transferred to any foreign government, under penalty of the forfeiture of the concession. Moreover, the time allowed in the concession for the completion of the canal has long ago expired, and this fact alone is a sufficient forfeiture of the original concession. Great efforts have been put forth to raise money for the scheme; all the same, the money has not materialized. The renunciation of the concession is, therefore, demanded. Perhaps, as a matter of statecraft, such a demand is right and proper; but to simple laymen it appears not at all essential that a man or company that has violated a contract should formally declare his renunciation of it, or that any government or governments should declare it, or declare anything at all except the fact that, by reason of the non-fulfillment of the agreement, all the rights and privileges specified in the agreement have lapsed and become of no effect. In ordinary business the method slangily but forcibly characterized as "firing out" would be the summary, and most probable, way of treating a delinquent of this sort. Our contemporary states what we believe all fair, broad-minded men will concede,—that England has no idea of obtaining control of this waterway, and that she, in common with the other great European powers, perceives that a "guarantee of neutrality by all the great powers is the only living status for such a waterway." This is the attitude of the powers toward, and the present status of, the Suez canal. If this be a just view of England's position, the outcry that has recently been made about her desire to gain possession and control of the Nicaragua waterway will be taken by most people at what it is worth for its possible service in helping the company out of its present plight.

Working Thin Coal Seams by Electrical Mining Machines.

MR. JABEZ HANFORD, in *American Manufacturer* (Jan. 8), expresses the suspicion (to put it mildly) "that some of our mining plants have not mined the thin seams of coal as economically as was previously done by hand." He also raises the question of the comparative economy of electricity and compressed air as motive power for mining machinery in general, but does not broadly discuss it. In considering this part of the subject, he refers to results attained by a plant constructed by the Ingersoll-Sergeant Drill Co., and makes a special comparison of cost per ton for coal-getting with this plant and the cost per ton of pick-mining previous to the installation of the Ingersoll-Sergeant plant, which consists of two 80-h. p. boilers, 60″ in diameter and 16′ long, one piston-inlet air-compressor, with a steam cylinder 20″ × 24″ and an air-cylinder 20¼″ × 24″, and ten mining machines of the intermittent cutting type. Upon the working of this plant Mr. Hanford makes a report, an abstract of which here follows: "Our seam of coal is known in the second geological survey of the State of Pennsylvania as the 'Darlington coal.' It is three feet thick and slightly undulating in character, with a band of slate one inch thick about three or four inches from the bottom. The roof is very strong slate, except where the workings are driven near the crop of coal, and the bottom is of soft fire-clay. The price paid for mining by hand is 70 cents per ton, screened coal. For driving entry, from $2.25 to $3 per yard; for airing, from 75 cents to $1 per yard. Price paid for cutting in rooms on this basis is 16 cents per ton, and 35 cents per ton for loading; for cutting entry and airways, 50 cents per yard, and 45 cents per ton for loading. The slate for height in the entries is afterwards taken down by the company. Mr. Hanford then makes an estimate of the cost of coal-getting by the compressed-air plant, including favorable and unfavorable times of year, finding that machine-mining in this mine effects a saving of 19$\frac{7}{10}$ per cent. on room coal alone, 18 per cent. on entries, 38 per cent. on airways, and 12$\frac{8}{10}$ per cent. on the total output. He further finds that, in the mine he is considering, compressed air is more economical and convenient than electricity for pumping; that the compressed-air machines are lighter, and, therefore, more easily moved about from place to place, than the electric machines; that in certain situations the air-driven machines may be used where the electric machines require so much space that their use becomes impracticable; and that in other respects the compressed-air machines are more convenient and safer to the men working in the mines than the electric wires. Mr. Hanford disclaims any intention of extending this comparison to other mines as a general conclusion in favor of compressed air as contrasted with electricity for mining purposes. He speaks only for the mine in question, attributing the good results very much to the particular adaptation of the plant to the existing conditions. The plant should harmonize with the conditions. "It is useless to try to harmonize conditions with a plant."

The Conducting Capacity of the Cast Weld Joint.

THE necessity of copper bonds in cast weld joints seems to be very clearly indicated by the results of tests made by Mr. Harold P. Brown, as recorded in an article from his pen in the *Street Railway Review* (Dec. 15). According to Mr. Brown, one of these joints was brought to the Edison laboratory some two years ago to be tested for its conductivity, the makers claiming that the joint was a better conductor than the rail itself, and that, therefore, a bond was unnecessary. Examination showed that mechanically the joint was all that could be desired, and a careful test showed the conductivity to be equal to a very good bond of No. 0000 copper. It was seen, however, that the cast iron was not actually welded to the steel; so, after burial in the earth for about two months, the tests for conductivity were repeated. The resistance of the joint had doubled in the interim. This is accounted for by the penetration of

water between the cast-iron and steel surfaces, not in perfect contact, and the consequent formation of a film of iron oxid. The mechanical performance of the cast-weld joints has proved excellent everywhere, but, even where bonded with copper, their resistance—at least after some time of use—is very much too high for economy. In Newark, Mr. Brown says, the average of several hundred measurements, excluding broken joints, showed the resistance of a foot of rail in each joint to be five times as much as that of a foot of rail between the joints, notwithstanding the joints were also bonded with copper, the copper bonds having been left in place at the time the cast-weld joints were made on several miles of 60-pound girder rails. Mr. Brown was so much interested in the matter that, after having his Weston instruments calibrated, he took them with him to St. Louis to see what he could there learn further respecting these joints. With reference to this part of his investigation, he says that a new cast weld joint was found to have a conductivity equal to about two No. 0000 copper bonds; that a year's use reduced this to about one-tenth of the initial conductivity; and that a little plug of Mr. Edison's plastic material reduced the loss to one-sixth at the start, and to one-fiftieth after a year's use. While in other cities the joint has proved very successful mechanically, it has been found "necessary to use a liberal amount of copper bonding in order to operate the road." In many instances the want of actual union between the cast-iron and the steel of the rail was very easily discernible.

Efficiency of Worm Gearing.

WHEN a very great reduction of speed is required, as is now often the case in the application of electric motors to machine driving, the very simplest means of effecting the desired result is the device known as worm gearing. This fact has of late brought it into prominence as one of the useful mechanical movements, and it has been substituted with much success for spur and level gearing that would otherwise have been required. All the same, worm gearing is still regarded with prejudice by many mechanics,—a prejudice which we confess to having shared. Only a set of favoring conditions, which, in many cases, can fortunately be secured, but which are impracticable in other cases, could induce us to adopt this method of reducing speed. One serious objection to reducing speed by the use of spur, bevel, and miter gearing has been the noisy character of their action; another is its cost as compared with that of worm gear. The objectionable noise, however, has been so mitigated by the use of rawhide gearing that, practically, it need no longer be much considered. Not so the cost, which will, under nearly all circumstances, exceed that of worm gearing. The conditions under which the latter may prove serviceable and economical cannot always be established and maintained. A good article on this subject (*American Machinist*, Jan. 21) states these conditions concisely. "The general line of change which has secured improved results has been in the use of steeper pitches than formerly, in the use of an oil cellar by which flooded lubrication is secured, and by the adoption of the Hindley form of worm. We should add to this the boxing-in of the gearing to exclude dirt in cases where much gritty dust is likely to foul the working surfaces. As we have said, all this is sometimes impracticable, and in any such case we should prefer a system of spur, bevel, or miter gearing, or, perhaps, a system comprising the three kinds. With such gearing we have lately reduced a very high speed to a very low one in a most satisfactory manner under conditions which, in our judgment, do not admit the employment of worm gear. A bugbear with many has been the supposed waste of power in friction by worm gear. The facts are generally the other way. If a series of worm gears had to be employed to gain the required reduction, there might be truth in this assumption of wastefulness. In general, a single worm gear will reduce speed as much as could be practically accomplished with three or four pairs of spur or bevel gears, and, although a single worm and wheel probably will give a higher co-efficient of friction than a single pair of ordi-

nary gears, the total consumption of power by such mechanism may well be less than that of the more complicated gearing. In the *American Machinist's* article are given the average results of tests made to determine the efficiency of this mode of transmission. These tests were made by the Sprague Elevator Company, which employs worm gearing in operating electric elevators, and were made with a balanced double worm, which avoids longitudinal thrust of the worm in either direction. The results are presented in two diagrams, one of which is for the Hindley worm and the other for the common worm. The curves on the diagram for the Hindley worm indicate the electrical output, the mechanical output, and the efficiency. The diagram shows only the curve of efficiency, a comparison of which with that for the Handley worm is much in favor of the latter. The ordinates of these curves represent amperes of current, and percentage of efficiency; the abscissas represent the pounds of pressure on the worms. The curve of mechanical output represents work actually done in hoisting the various weights,—translated into equivalent current. The mechanical-power output is, of course, the product of the weight lifted by its speed, while the electrical power input is the product of the volts by the amperes. The speed and voltage are fixed, and hence may be ignored, or, more properly speaking, canceled, and the weights lifted compared directly with the amperes supplied." The results of more extended tests, with worms of different pitches, intended to show the effect of variations of pitch, are promised from the same source at an early day, and the data to be thus supplied will have a much wider interest than they would have had prior to the present extended use of electric motors.

The Purification of Water.

DR. FRANK J. THORNBURY, in *The Chautauquan* for February, says that, in the absence of bacteria from water which comes from artesian wells and springs after its percolation through the earth, there is an important suggestion of means for improving the character and potability of water. Dr. Thornbury is a lecturer on bacteriology in the University of Buffalo, and is a recognized expert on this subject. He says that the forces of gravity and capillarity explain the process, minute capillary streams being formed which run in all directions through the soil. When the coarse texture of the soil is considered, it is, perhaps, rather to be wondered at that greater numbers of bacteria are not carried into the lower strata, but the depth of the soil through which the water percolates before it again reaches the surface explains this discrepancy. The huge sand-filters employed in a number of municipalities, both in America and Europe, are, therefore, merely more or less close imitations of nature's method, and, in proportion as they approximate to that method, their success has been greater or less. Most of them can hardly yet be regarded as brilliant successes, although the water so treated not only has been improved, but in some cases has been brought to a condition permitting its use for domestic purposes. Nature's great method of purifying water is filtration. This means not merely the removal of the floating particles that may be mechanically obstructed by the sand particles, but also those minute living germs that would readily pass through a small filter of almost any material. "When we consider the fact that a number of natural water-supplies which were originally pure have become, as the penalty of increasing population, virtually diluted sewage, we must realize the extent of refuse which will accumulate in one of these filter-beds after only a short usage. And, strange to say, it is the mechanical action of this sediment itself, which swarms in low forms of vegetable life, that is to improve the filtering capacity of the sand-bed. The sediment occludes the pores which will be present in even the finest sand obtainable. A filter like the foregoing is, then, simply a dense bed of bacteria and slime, composed largely of vegetable degenerated substances. Notwithstanding all this, water which passes really seems to improve as regards the number, at least, of the bacteria which it contains. But, as

the bacteria which appear in the effluent are not entirely a residue of those which have entered, but rather represent organisms which have been washed from the deeper portions of the filter, we may readily see that, if the filter had been contaminated by a transitory passage of foul sewage containing perhaps pathogenic organisms, water might be deteriorated rather than improved in its quality. Where such a system of purifying water is employed, the water should be sedimented for two or three days by simply allowing it to stand, so that some, at least, of the impurities—gross and bacterial—will be disposed of and the filter given less to do." One of the important facts pertaining to the use of filtered water, which should be impressed upon the minds and memories of all who use such water, is the fact that bacteria rapidly reproduce and multiply in it. Hence such water should not stand long before its use for any purpose concerned in the preparation of food. Dr. Thornbury holds that efficient filtration is rather a biological process than a mechanical one, and that, the sooner this fact is realized, the sooner will the much-needed improvements in artificial filtration be made. Nature's filtration is intermittent, and "the value of intermittent filtration in the disposition of sewage by the sewage-farm system has been amply illustrated by experiments conducted under the auspices of the Massachusetts board of health." The author sustains Wyatt Johnson's assertion that ninety per cent. of all domestic filters are absolutely unreliable, and that the remainder are good only when cleaned and sterilized at least once a week.

The Operation of Long Electric Railway Lines.

PROFESSOR S. H. SHORT, in *The Electrical Engineer* (Jan. 6), makes some interesting practical suggestions upon the operation of long, interurban, electric railway lines. Noting an increased demand for heavier equipment and higher speed in this sort of traffic, and the facts that this demand has brought into existence "double-truck passenger coaches equipped with motors ranging from fifty to one hundred horse power," and that several roads in the United States are running trains of from two to three of these cars, which, by the overhead trolley system, are brought into the hearts of cities over the ordinary surface lines of the street railway companies, he points out the difficulty "that apparatus for this suburban traffic must be constructed to develop much greater speed than can be permitted within city limits. In existing practice, two motors of large size are used and regulated by an ordinary series multiple controller. If these are geared to run forty miles an hour at full speed on the parallel position of the controller, their minimum speed would be twenty miles per hour on the series position, unless considerable rheostat resistance be included in circuit, which is both wasteful of energy and destructive to the resistances themselves." Instead of using two motors, Prof. Short suggests four smaller ones, one on each axle of the motor car, and the employment of a controller which, "when the motors are grouped in parallel, will develop a speed of forty miles per hour, in series parallel a speed of twenty miles an hour, and in series a speed of ten miles an hour," the latter being the maximum speed now permitted in city streets. If this suggestion were carried out, several important advantages would result. Among these are increased adhesion—twice as many wheels acting as drivers. To obtain the requisite current from the supply conductor, several ways are indicated. "Two or more trolleys may be arranged, one behind the other, and connected in parallel, each taking its portion of current from the trolley wire; or, perhaps better, a single trolley with a cylinder of some length attached to the upper end of the trolley pole, making contact with two or three current-carrying trolley wires. These trolley wires would be connected in parallel, and would reduce the size of the feeders of the line. Over switches and sidings these wires could be separated, as one wire could carry sufficient current for any short distance." The overhead trolley system, however, is regarded as impracticable for long distance, cross-country roads, which must rival steam railways in weight and dura-

bility of equipment. For roads of this kind the "third rail" system is advocated, this rail to take its current from a main extending the full length of the road, to be placed in a conduit at one side of the track, and to convey current to the motors by means of contact shoes attached to the front and rear trucks of the motor car. Prof. Short regards alternating motors as, in themselves, solving part of the difficulties here outlined, provided some way can be devised to increase the torque needed for starting. This point is receiving attention, and the defect has been overcome in some measure. A great advantage of the alternating current motors is the practicability of regulating speed on different sections of the road. But the adaptation of alternating current motors to street-railway propulsion presents such difficulties that, as yet, the direct current motors have the field. Should the direct conversion of the potential energy of carbon into electrical energy prove to be something more than a chimera, the problem of electrical propulsion for railways would be vastly simplified. We are of those who believe that this will at some time be accomplished, notwithstanding the cold water which some electrical authorities of influence and standing have of late thrown upon what has already been done in this direction.

The Electric Yacht Utopian.

A BRIEF illustrated description of this yacht appears in *American Electrician* for January. The article deals as much with the marine engineering features of the boat as with its electrical outfit. The latter is chiefly remarkable because the largest storage-battery ever installed for boat-propulsion has been supplied to the vessel. Of course, there are numerous electrical appliances. These, however, are now common on board vessels of this class, and little need be said about them. The construction of the hull presents novelty. The boat's length is 72 feet, beam 12 feet, and draft 12 feet. She was designed by Mr. Charles D. Mosher, and built in Ayres' ship-yard at Nyack on the Hudson.

The propellers are placed in channelways arranged to give the screws solid water to work in. The screws are capable of a speed of twelve hundred turns per minute. We believe that such a speed for these screws will prove less efficient than a less speed and larger screws. The appearance of the model at the stern is peculiar, on account of this channel-way construction. A difficulty attends this arrangement of screws in channel-ways, when boats are intended to ply in waters prolific in aquatic plants. The screws are liable to entanglement. Two Tobin-bronze center-boards, one placed about one-third the vessel's length aft of the bow, and the other about the same distance forward of the stern, are supplied. A separate 25-h. p. Riker motor is directly connected with each screw shaft. "The storage-batteries are of a new system, having no grid plates, and furnished by the Samuels Dynamic Accumulator Co., of New York. The positive plate is solid, and very hard and dense, and is said to improve in its durable qualities with use. Each cell has eleven plates weighing twenty-six pounds, the cell complete, with electrolyte, weighing only fifty pounds. Each cylinder has its own controlling battery, the latter being of 300 ampere hours' capacity, and consisting of 204 cells. The cells are divided into 6 independent groups of 17 pairs of cells each—each pair being parallel, and the 17 pairs in series, thus giving 34 volts for each group. Six groups, by means of the controller, can be thrown into four different combinations, . . . and the motor field may either be in series or parallel, which gives eight different speeds for the propellers. . . . The first four combinations are employed for both backing and ahead, and the latter four for ahead alone." The boat will also be schooner rigged, and can thus be propelled by wind, if occasion demands.

Allotropism of Iron.

THIS subject, which appears to come up for discussion from time to time, is again considered by Mr. Henry M. Howe in *The Engineering and Mining Journal* (Dec. 12). As proof "that iron becomes allotropic in the broad sense of the word, in

the critical range of temperature," he cites the fact that iron "nearly chemically pure and apparently free from carbon, in cooling slowly through the critical range of temperature, regains its magnetic properties rapidly, and twice spontaneously emits heat at definite, well-marked temperatures.

The important question whether the retention of this allotropic iron by sudden cooling be one cause of the hardening of steel would be answered affirmatively, if it could be shown that some of the effects which we group together under the general name of hardening can be produced under such conditions that no cause other than this known allotropy suffices to explain them." In a former paper, read before the Iron and Steel Institute, Mr. Howe presented a number of cases wherein iron containing a very small percentage of carbon was strengthened and embrittled to a degree which in his opinion was too great to be attributed to the carbon. Thus steel containing only 0.06 per cent. of carbon had its tenacity nearly tripled. Another instance is cited wherein "iron containing only 0.02 per cent. of carbon and very little manganese or any other element had its tenacity increased by 35 per cent., and its elastic limit raised by 81 per cent., by a cooling which was only moderately rapid." Following this are tabulated results of a series of experiments carried out at the works of the Pennsylvania Steel Company with bars of equal size cut from a block of steel containing only 0.04 per cent. of carbon, such of these bars as were quenched showing a much greater tenacity than those that were cooled slowly. He admits that these results *may* be "due jointly to the direct action of the foreign elements so sparingly present, and to stress and other causes yet unsuggested;" but he thinks it "as difficult to explain them in this way as it is easy to explain them by supposing that the allotropic iron . . . has been in part retained by the rapid cooling," and that allotropic iron "is stronger, but less ductile, with higher elastic limit, than iron in the normal state reached by slow cooling."

A Plea for Simplicity in Plumbing-Work.

WE are in receipt of a pamphlet written by Mr. Wm. Paul Gerhard, a civil engineer who has given a great deal of attention to the heating, ventilating, drainage, and sanitation of dwellings and public buildings, and who has made a specialty of sanitary engineering. Mr. Gerhard is also widely and favorably known from his numerous treatises and papers on sanitation and kindred topics; therefore the opinion he expresses in the particular pamphlet here noticed, entitled "Plumbing Simplified," will command attention. Doubtless the view that a simpler and less costly system of plumbing than is now practised can be made equally serviceable and effective will be combatted, especially by those whose commercial interests lie in maintaining the use of current appliances. If, however, Mr. Gerhard has fortified his view by irrefragible arguments, the employment of simpler modes will be only a question of time. Early in his essay the author makes an avowal of his advocacy of good, sound, and safe plumbing-work, and puts in a disclaimer of any "personal interest in any patented plumbing device or in any special trap," thus defending himself in advance against a suspicion that his views are biased by motives which such an interest might create. The law that "all traps must have a vent-pipe of suitable size connected at or near the crown of the trap, and extended separately up to the roof or connected with the soil-pipe line above the highest fixture," first put in force in New York, Boston, and some other cities, has been widely copied by many smaller cities and towns, which action is regarded by Mr. Gerhard as a mistake. He makes the following objections to this law: "(1) The venting of traps leads to a greater, and sometimes dangerous, complication of the work; (2) it involves a useless outlay of money; (3) it increases, and often doubles, the number of pipe-joints in a building; it duplicates the pipe system, and therefore increases the danger of leakage at the joints; (4) trap vents attached to the horns of porcelain fixtures, such as water-closets, often lead, in case of settlement of the

building, to the breakage of these horns, thus opening up a dangerous inlet for sewer air, the crack often remaining unnoticed for years; (5) the mouth of the vent-pipe at the point where it attaches to the crown of the trap is liable to clog up with congealed greasy deposit, rendering the vent-pipe useless without this fact becoming apparent to the occupant of the house; (6) the upper end of the back air pipe, when it extends separately to the roof, is liable, unless enlarged to at least four inches in diameter, to be closed up with snow or hoar frost in winter time; in very cold climates even a four-inch pipe may become sufficiently obstructed by hoar frost or icicles to impede seriously the free ventilation of the vent-pipe; (7) owing to the increased air current passing over the water-seal of the trap, and induced by the vent-pipe, the destruction of the water-seal by evaporation is more rapid; (8) the trap venting system affords increased opportunities for bye-passes in the case of careless or ignorant workmen; (9) in the case of long vent-pipes, particularly where there are several sharp bends in the pipe, the friction of the air passing through the pipe is sometimes increased to such an extent that the vent-pipe fails to protect the trap from siphonage." Surely here is an array of objections to the system of trap-venting that challenges serious attention. The author, while he uses with the simple S-trap a back air pipe for preventing siphonage, asserts his belief that "branch-pipe ventilation is carried much too far"; that "it creates new and sometimes serious dangers"; and that "it entails an unnecessary and useless expenditure of money." To the argument that trap-vent pipes are not alone for the purpose of preventing siphonage, but also for aerating branch pipes and maintaining circulation of air in the entire system of branches, the answer is made that "plumbing-work can, and should, be always skilfully arranged and planned, so that the fixtures are located immediately adjoining well-ventilated soil- or waste-pipe lines. If thus arranged, the short branches will be so well flushed by the frequent discharge from the improved modern fixtures with large outlets—each of which constitutes in itself a small flush-tank—as hardly to require any other purification or aeration." And he urges that only fixtures having the features named are suitable for plumbing-work. A description of the simplified method illustrated by diagrams can not be here reproduced, but it appears to confirm the claim that this method is generally practicable. Rules desirable to observe when planning the system are given. Finally, the author claims to be able to prove experimentally that "security against back pressure, loss by momentum, evaporation, siphonage, and loss of seal by capillary attraction may unquestionably be attained by the method described." The paper is both progressive and aggressive. It closes with a prediction that "the trap-vent law will ultimately be repealed, and that simpler and better methods will take its place." If the system proposed by Mr. Gerhard is better than, or, as we are willing to concede, even as good as, the trap-vent system, its superior cheapness is sure to force it to the front.

Cost of Boiler Attendance.

LIGHT has been thrown upon the subject of boiler-room economy by information contained in circular No. 6, of the Steam Users' Association. Investigations disclose the following facts. The average cost of handling coal in boiler-rooms is forty-five cents per ton, the minimum cost twenty-six cents, and the maximum eighty-five cents. The maximum is, therefore, very nearly four times the minimum. While the contention of the circular that this indicates the possibility of improving methods of handling coal in supplying fuel to boilers may be readily admitted, practical men will see that the question of cost in handling must depend in considerable degree upon the quantity daily consumed. This has not been overlooked by the investigators in the conclusions arrived at. These conclusions are not put forward as rigidly accurate, but as sufficiently close approximations to answer the purpose of their publication. Those who have not received the circular will find these con-

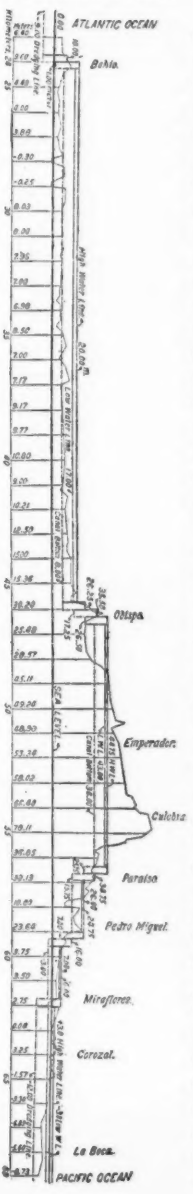
clusions systematically printed in due order in *Engineering News* (Jan. 28).

Electric Arc for Lantern Projection.

THOSE who desire to use lantern projection in illustrating lectures will find some useful hints upon the use of the arc-light for this purpose in the first number of a series of articles by E. P. Hopkins, commenced in *The Electrical Engineer* of December 12. The illuminants hitherto used for this purpose have been oil lamps; illuminating gas, used with the argand burner, and, later and better, with the Welsbach burner; acetylene gas; the oxyhydrogen or calcium light; the electric incandescent light; and, last and best of all, the electric arc light. Mr. Hopkins' first article describes a method of obtaining the most satisfactory results from the arc-light The conditions to be attained are the illumination of the slide as uniformly as possible, and the use of as small an illuminant as possible. The first condition is obtained with a short focus by means of two condensing lenses, and the illuminant can be reduced more nearly to a point in the electric arc than by any other known means. The mounting of the condensing lenses must be such as to permit their expansion when heated, and, with a current of from seven to eighteen amperes, a combined focus of three inches with a pair of condensing lenses is perfectly safe. With the electric arc such an arrangement can be made that, at the extreme point of the positive carbon, an area of three-sixteenths of an inch in diameter will emit eighty per cent. of the entire light; and, by tilting the lamp so that the extremity of the positive carbon points toward the condensing lenses, the spot of light from the negative carbon can be avoided. The concentrated rays may be passed through an aperture of one-eighth inch in diameter,—a necessity in microscopical projections.

The New Panama Lock Canal.

FROM our excellent contemporary, the *Railroad Gazette* (Jan. 15), we are able to able to make an abstract of the present status of the Panama canal scheme as an engineering enterprise. That journal prints an illustrated article upon the subject, with a profile, which we reproduce on a somewhat smaller scale.



The profile is that of the plan now provisionally adopted, which contemplates the utilization of the work already accomplished. "The elevation of the summit level (bottom of channel) will be thirty-four meters above mean sea level. Though this elevation of thirty-four meters is adopted as a starting-point for the proposed work, it is not to be considered as unchangeable. The company will endeavor, either during its investigation or while the work is in progress, to lower, as far as possible, the channel at the divide below this elevation of thirty-four meters, should the conditions for excavating the large cutting which will constitute the divide be found favorable." On the Atlantic side the tide is not sufficient to demand consideration, and the harbor channel on that side will be at about the sea-level. At the Pacific end a variation of six meters between high and low tide must be allowed for. To reach the elevation of thirty-four meters above the sea-level will require a rise

from the channel-bottom of forty-three meters on the Atlantic, and forty-six meters on the Pacific, side. Five locks—maximum lift 10 m.—on each slope will be used to get the required rise. "On the Atlantic slope are two successive locks at the kilometric point 24, at Bohio Soldado, and three successive locks at the kilometric point 46, at Obispo. On the Pacific slope are one lock at Miraflores, kilometric point 62; two successive locks at Pedro Miguel, kilometric point 59; and two successive locks at Paraiso, kilometric point 56.500. "The successive levels will be determined by the locks, and by the dams which close the valleys transversely where the locks are to be placed. These locks will, therefore, form lakes of varied extent to receive directly the waters for the canal. The only really important one will be the one for the locks and dams at Bohio. This lake, which will have a surface of about 1.16 square miles, will receive, besides the Chagres river, whose flow is to be regulated by a higher lake, . . . the tributaries of the stream of water between the summit level channel and the dams in the valley at Bohio. . . . The discharges from the lake will be led through special waterways below the dam." The supply of water for the locks will be taken from the Chagres river, for which purpose a scheme of regulation and control of floods has been worked out. The locks will be constructed to take in the largest trading vessels. The width will vary, and locks and basins will be provided to facilitate the passage of vessels through the canal. The statement is made that the company has taken all necessary measures for the rapid progress of the work, the successful completion of which is expected in about two years from the present time. We may hope, thus, to have the two oceans connected before the beginning of the twentieth century.

A Metric-Conversion Table.

THE January issue of *Engineering Mechanics* contains a very handy metric-conversion table compiled by Mr. C. W. Hunt, of New York city. The particular convenience of this compilation is the expression of the factors in such form that the conversions ordinarily required may be effected by one direct operation of multiplication.

The table is reproduced below. *Engineering Mechanics* states that Mr. Hunt has had copies prepared, which he will furnish on request if stamps are enclosed.

Millimeters × .03937 = inches.
Millimeters ÷ 25.4 = inches.
Centimeters × .3937 = inches.
Centimeters ÷ 2.54 = inches.
Meters = 39.37 = inches (Act of Congress).
Meters × 3.281 = feet.
Meters × 1.094 = yards.
Kilometers × .621 = miles.
Kilometers ÷ 1.6093 = miles.
Kilometers × 3280.7 = feet.
Square millimeters × .0155 = square inches.
Square millimeters ÷ 645.1 = square inches.
Square centimeters × 1.55 = square inches.
Square centimeters ÷ 6.451 = square inches.
Square meters × 10.764 = square feet.
Square kilometers × 247.1 = acres.
Hectares × 2.471 = acres.
Cubic centimeters ÷ 16.383 = cubic inches.
Cubic centimeters ÷ 3.69 = fluid drachms (U. S. P.).
Cubic centimeters ÷ 29.57 = fluid ounce (U. S. P.).
Cubic meters × 35.315 = cubic feet.
Cubic meters × 1.308 = cubic yards.
Cubic meters × 264.2 = gallons (231 cu. in.).
Liters × 61.022 = cubic inches (Act of Congress).
Liters × 33.84 = fluid ounces (U. S. Phar.).
Liters × .2642 = gallons (231 cu. in.)
Liters ÷ 3.78 = gallons (231 cu. in.).
Liters ÷ 28.316 = cubic feet.
Hectoliters × 3.531 = cubic feet.
Hectoliters × 2.84 = bushels (2150.42 cu. in.).
Hectoliters × .131 = cubic yards.
Hectoliters ÷ 26.42 = gallons (231 cu. in.)
Grammes × 15.432 = grains (Act of Congress).
Grammes × 981 = dynes.
Grammes (water) ÷ 29.57 = fluid ounces.
Grammes ÷ 28.35 = ounces avoirdupois.
Grammes per cu. cent. ÷ 27.7 = lbs. per cu. in.
Joule × .7373 = foot pounds.
Kilograms × 2.2046 = pounds.
Kilograms × 35.3 = ounces avoirdupois.
Kilograms ÷ 1102.3 = tons (2000 lbs.).
Kilograms per sq. cent. × 14.223 = lbs. per sq. in.
Kilogrammeters × 7.233 = foot pounds.
Kilograms per meter × .672 = pounds per sq. ft.
Kilograms per cubic meter × .026 = pounds per cu. ft.
Kilograms per cheval vapeur × 2.235 = lbs. per h. p.
Kili-watts × 1.34 = horse power.
Watts ÷ 746 = horse power.
Watts ÷ .7373 = foot pounds per second.
Calorie × 3.968 = B. T. U.
Cheval vapeur × .9863 = horse power.
(Centigrade × 1.8) + 32 = deg. Fahrenheit.
Francs × .193 = dollars.
Gravity, Paris = 980.94 cent. per second.

THE BRITISH PRESS

The Status of Civil Engineering in England at the Beginning of 1897.

A RETROSPECT of the past year's progress in civil engineering and an attempt at forecasting its future for the current year fills several editorial columns of *The Engineer* (London, Jan. 1). This editorial asserts that the British engineers do not retain the prestige they once possessed among continental nations, but it does not blame them for the decadence. This is attributed to various causes, among which are included the endeavors of purely theoretical professors and tutors "to force upon the" (British) "working men and youth . . . an alien system of education, defective *per se*, theoretical to the point of absurdity, and repugnant to the feelings and sentiments of those for whose benefit it is supposed to be intended." There is here an intimation—amounting almost to positive assertion—that a scale of education may be raised too high—so high, in fact, that it will be rejected. "Raise the standard of education as high as the Himalayas, or higher if possible, but, if it is not a scale 'understanded of the people,' they will have none of it." This alleged attempt is called "a fatuous blunder," resulting in a diminution of eagerness in the search for knowledge on the part of the British public. Exactly how this "fatuous blunder" has resulted in the loss of continental prestige is not made clear; but it is frankly conceded that the field for the enterprise and talent of British engineers, as compared with that of a former period, has been much contracted. As a fact of the end-of-the-century tendencies this contraction is discussed, not as a cause for discouragement, but as a development that ought to have been foreseen and discounted. It was not possible for British engineers to create and maintain so broad a demand for their services as at one time prevailed; and, while there is still room for the exercise of their skill, both in the United Kingdom and to a less extent on the continent, they are now advised to go further afield. India, Canada, Australia, and the numerous other British possessions are spoken of as likely to supply the desired scope and opportunities for the rising generation of English engineers. Some self-congratulation upon the number and extent of these dependencies is indulged, and the advantage they afford to British talent as compared with the comparatively meager possessions of continental nations is dwelt upon in a brief forecast of the probable results of modern improvement in these far-off lands. The humiliating reflection that, while Great Britain has been active in the acquisition of territory,—thus enlarging the scope of effort for native-born Englishmen,—the United States government has been giving away its domain to foreigners and aliens, thus restricting the opportunities of its native-born citizens, has been painfully forced upon us in this review. Of all the great nations of the earth, the United States alone has committed this monumental folly.

Cottage Architecture.

AN agreeable and thoughtful article on this subject by Mr. Ralph Neville, in the *Journal of the Royal Institute of British Architects* (Dec. 31), presents a discussion under the following four heads: (1) Accommodation; (2) the style; (3) the plan; (4) the material. We have long thought that cottage architecture affords a field for the exercise and cultivation of artistic feeling which, if not equal to the possibilities of large, stately buildings, may confer gratification upon those whose taste has not had the broadest opportunities for cultivation, as well as upon those who are landscape artists in the full sense of the word. A cottage and its surroundings, no matter how humble or inexpensive, may form so attractive a picture that even a trained artist would take pleasure in beholding and studying the secrets of its charm; the more highly trained the artist may be, the more likely it is that he will delight in charming effects produced in the simplest way. A true lover of beauty does not gage his fee of admiration by any social or conventional scale whatever. A

difficulty which usually accompanies the design of a cottage—the slender sum which can be devoted to the building—seems to a class of mind somewhat above the monotonous plane of money-making to add to the interest of the subject. The art of making beautiful that which is at the same time inexpensive seems to be art the cultivation of which the whole mass of humanity would benefit by. The cottages treated by Mr. Neville are of the humbler order, such as are occupied by rural laborers; and Mr. Neville throws a dash of good sense into his paper almost at the outset, when he deprecates as futile and foolish the efforts of some to induce cottagers to use their best rooms for ordinary purposes. "Experience convinces one of the necessity of bowing to one of the deepest seated instincts of cottage-dwellers." The question is whether cottagers are to have a kitchen as well as a scullery big enough to be turned by squeezing into a working kitchen. "The kitchen will then infallibly be turned into a parlor, which will be shut up except on Sunday afternoons or to receive the visits of 'the quality.' . . . Certain it is that they will leave a large, roomy cottage of the old sort for a modern one where they can have this luxury." Of style it is maintained that the straining for effect through the sacrifice of simplicity should be strongly deprecated. It adds to cost without any adequate return, and employs money that ought rather to be applied to making the interior more comfortable. In proportions, rather than in ornamentation, pleasing effects are to be sought. A plain exterior (except that some attention may be bestowed upon the front windows), roofs sought by lichens and low eaves by creepers, may be made to satisfy the eye of taste much more completely than the fantastic shapes by which many designers seek a beautiful effect, which they never obtain by such means. The plan of modern laborers' cottages mostly follows the line of erection in pairs, or in blocks of four, the purpose being economy in chimney stacks. The design of interiors, which Mr. Neville discusses at some length, has evidently been very carefully considered. The reader who desires to follow all these details must consult the article itself. Of materials, although locality will much influence selection, one particularly is recommended as everywhere available and in every way adapted to the purpose. This material is concrete, and its convenience and value are strongly asserted. Some remarks on the restoration of old cottages conclude the article.

Progress in Electric Engineering from an English Standpoint.

In a rapid review of electrical work during 1896, *The Engineer* (London, Jan. 1) notes that there has been a very satisfactory increase of business in this field, and that at the commencement of the present year a very large number of electrical engineering establishments had orders for all they could possibly do for a period of six months. All indications point to equal prosperity in 1897. Electric lighting has a preëminence in England over other branches of electrical engineering. The country does not possess numerous and large sources of water power, which can be advantageously and profitably distributed by the electric current when generated, as is the case in North America and other parts of the world. Distribution of mechanical power therefore holds in England a place far below that which it holds in the United States. In electric lighting municipal control appears to be the rule in England, and there is apparent a strong tendency in its favor. In the United States many (including this magazine) believe that municipal control would ultimately result in a less satisfactory and a more expensive supply than is now obtainable from the electric-lighting companies. But the opposite is alleged to have been the outcome of municipal control in England. The system has in some cases imposed delay in obtaining the desired supply; but in nearly all cases it has resulted in the employment of a competent engineer, under whose advice well-designed and thoroughly-equipped stations have been installed. While in some instances gas-works and electric-lighting plants are worked together, experience is proving

that this is not the best plan, and there is a growing tendency toward a policy of separation. "As a rule," says our cotemporary, "there is quite sufficient room for the development of both sources of supply." Where, as in Belfast, gas departments supply gaseous fuel to the electric-lighting plants, the arrangement is said to have been, in some instances, at least, not altogether satisfactory. On the other hand, the employment of special producer-gas plants to supply power for electricity stations appears to be of great promise. Of this system it is asserted that it has given the lowest coal consumption yet attained. Several stations working upon this system are named, and results attained in them have presumably contributed to the favorable opinion expressed. The state of opinion among the designers of central-station steam-generating plants regarding many things (for example, the best type of boiler, and the economy secured by superheating steam) is still unsettled. Of superheating it is said that "considerable discussion has taken place as to whether the economy that appeared to be obtained was actually due to the system of superheating employed; and so far no trustworthy data are obtainable which will prove whether superheating *per se* is so economical as would appear, or whether the particular results set forth are due to the type of generating plant in use. It has always appeared to us somewhat strange that such a diversity of opinion should exist between the designers of central-station steam-generating plant and the designers of similar plant for mill work and other purposes of the same nature. The latter appear to have long since decided in favor of the Lancashire boiler, while there seems to be no unanimity whatever in the designs of the former. . . . No unanimity is as yet evident in the type of plant selected for the generation of electricity, although there appears to be a tendency to use large fly-wheel alternators for the generation of alternating currents in preference to the use of belt or rope-driven machines running at higher speeds." The results so far attained by rectification of alternating current are not yet regarded as convincing evidence that they warrant the extra attention demanded in the application of this system. It is thought that a potential of two hundred volts will soon become the standard of supply from direct-current stations; and attention is directed to the increased care needed in the wiring of buildings for electric lighting which this increase of voltage will demand. Electric heating and cooking have as yet made small progress in England. Notwithstanding the probability of a great future for the fly-wheel alternator in producing alternating current, our contemporary still believes direct-driven plants for direct currents will be most desirable. Gas engines working with producer gas and driving dynamos direct are among the probable competitors of steam engines for electric-lighting plants. One installation of this sort (developing 164 brake horse power) is spoken of as working satisfactorily. It is believed that a considerable extension of electric tramway construction will soon be witnessed in England, as electric power for this purpose is growing in favor. Electric welding is also gradually extending, and the outlook for general electric engineering is very bright.

The Bearings of the Marine Engine.

WITH increased steam pressures and increased power for propelling ships the difficulties with bearings have been much increased,—difficulties which those inexperienced with marine machinery would scarcely credit. It was said of the ram Dunderberg, after her purchase by the French government, that, during her passage across the Atlantic, her bearings could be kept moderately cool only by a constant deluge of oil and water; in fact, provision for cooling bearings with jets of water is a common feature of modern marine engine construction. In a paper read before the Institute of Marine Engineers by Mr. John Dewrance, the author presents the results of an experimental study of lubrication under heavy loads, and of the manner in which oil enables a bearing to support its load. The method adopted—which is illustrated in the paper

as printed in *Engineering* (Jan. 1)—consists in the employment of a wheel twenty-four inches in diameter and representing a shaft, a flat plate which may represent an enlarged bearing, and a trough placed in such relation with the wheel that oil placed therein may rise to the plane of the bearing surface of the wheel. Before putting the oil in the trough, if a micrometer be adjusted to indicate the position of the wheel, its index will stand at some determinate mark. "If oil is now put into the trough so that it touches the wheel, it will be observed that the hand has moved, showing that the plate has risen. This means that between the surface of the wheel and the bearing there is a layer of oil on which the bearing is floating. If we now load the bearing, we must either squeeze out this layer of oil, or the oil must be subject to a pressure sufficient to support the extra load. By means of a hole through the bearing and a pressure gage, this point can very readily be proved. As will be seen, as the hole is brought to the point of contact between the bearing and the shaft, the pressure on the gage rises to a point that corresponds to the load put upon the bearing. . . The oil adheres to the surface of the wheel or shaft, and the force of this adhesion is multiplied by the incline formed by the bearing to the shaft. If the hole is put beyond the center of the shaft, the air in the hole adheres to the shaft and is carried around, leaving a vacuum as shown by the gage. Under favorable circumstances this vacuum has amounted to thirty inches of mercury column." The conclusion cannot be avoided that bearing surfaces properly lubricated with oil are separated by a film of oil under a pressure per square inch corresponding with the load (per square inch) to which they are subjected. The secret of good lubrication is, therefore, the introduction of oil to the bearing surfaces at points of least pressure, and the prevention of its escape from points of greatest pressure. Mr. Dewrance thinks it easy, in general, to find out the points of least pressure on a bearing, and to bring the oil to these points by the exercise of a little ingenuity. Holes and channels designed to assist lubrication not unfrequently defeat the purpose they are designed to subserve. Oil-holes and channels at the crown of the bearing, where pressure is greatest, are worse than useless. "When the pressure on such a bearing is intermittent, the oil goes in when the pressure is taken off, and escapes out again when the pressure comes on, the effect being that the bearing is able to support only a portion of the load that it could have sustained," had holes and channels been made at points of least pressure. "It is quite impossible to lubricate such a bearing at all, if subjected to a continuous load. Not a drop of oil will run down the hole at the crown of the bearing, and, if oil is put on the shaft elsewhere, it runs out at the hole at the crown." Having considered these underlying principles, the author describes and illustrates their application to the bearings of a marine engine and propeller shaft. In the case of the thrust-block, as commonly constructed, there is no point of least pressure at which the oil can be introduced, but such a provision may be made by slightly sloping off the edges of bearing surfaces, which, Mr. Dewrance declares, will, when so formed, draw the oil in between the surfaces up to any pressure.

"Another very important point is the material of which the bearing is composed. Marine engineers seem to be very generally agreed that the bearing should be lined with one of the alloys known as the white metals. These may be divided into three classes. The first contains anything up to eighty per cent. of tin, the second anything up to eighty per cent. of zinc, and the third anything up to eighty per cent. of lead. If we could make sure of always using perfectly neutral oil, there would be very little to choose between these three classes; but, to obtain a neutral oil, such as is prepared for clock-makers, the oil is agitated with zinc and lead shavings, and a portion of each is converted into zinc or lead soap, which is afterward separated from the oil. The principal impurity of lubricating oils is oleic acid, which rapidly corrodes lead and zinc. . . The effect, then, of using an alloy that contains a large proportion of lead or zinc

is that the impurities of the oil combine with the surface of the bearings. Of course, this may be avoided by using a very pure oil, but those that are responsible for the lining of the bearing are not always responsible for the quality of oil used, and, even if they are at the time, they can not make sure that they will always have it under their control. Tin is not affected by oleic acid or any of the impurities of oil; so the safest way is to use an alloy composed principally of tin, and containing only enough of the most suitable metal to harden it to the utmost." Alloys that yield under a load of less than five tons to the square inch are too soft; "the best alloys will bear eight tons without yielding." The alloy should be hard enough without hammering. Hammering is disapproved, because, if the metal be as hard as it ought to be, hammering fills it with minute cracks, and, if so soft as to require hammering, it should not be used at all for the lining of marine bearings.

Brickwork Tests.

THE uncertainties and discrepancies that attend tests of the strength of brickwork are very forcibly exemplified in the following table, extracted from an editorial upon the subject in *Engineering* (Jan. 1). One of the very ablest experimenters in the United Kingdom, Prof. Unwin, made the tests from which the data are taken, acting for the Institute of British Architects. An inspection of the table reveals these discrepancies. One of the reasons why so widely-varying results are obtained in almost any extended series of brickwork tests is the great variety of conditions. The quality and mode of application of the cement or mortar in which the bricks are laid; the nature of the weather while the wall is going up; the rapidity, thoroughness, or lack of thoroughess with which the work of bricklaying is done; the quality of the bricks used, —all these are factors in the final strength and enduring power of the structure when finished and tested. This is but to repeat what is well-known to all designers and builders of brickwork. All the same, most engineers, architects, or masons, setting out to attain a prescribed factor of safety in a brick structure,—say, an arch, —would attain the end by giving it a strength known, or reasonably assumed, to be in excess of the strength specified, and would shrink from working from a calculation that theoretically confined the factor to so narrow a margin of error as would be permitted in a machine built of steel or cast iron. The iron and steel worker has the advantages that much greater accuracy in results can be secured in testing the quality of the material used, and the confidence that, when this strength is determined, it may be relied upon to present a fair degree of uniformity. On the other hand, the mason, even if he be satisfied that the quality of the cement used is good, and that it is tolerably uniform throughout, immediately finds himself confronted with the personal equation of the workmen, variations in temperature, changing hygrometric conditions, etc., each of which is almost sure to affect the final result more than one, or all, of them are ever likely to influence a job performed in a machine-shop under faithful and competent direction. The table which has called out the above remarks here follows:

Table of Brickwork Tests.

Material of Pier.	Crack'd at	Collapsed at	Average Strength of Single Brick
	tons per sq. ft.	tons per sq. ft.	tons per sq. ft.
London stocks in mortar	4.18	10.41	84.27
London stocks in cement	7.22	16.03	
Gault in mortar	5.00	21.82	182.2
" " "	6.16	23.03	
" " cement	6.98	17.98	
" " "	7.08	17.51	
Leicester red in mortar	15.20	29.93	382.1
Leicester red in mortar	16.11	31.55	
Leicester cement	17.87	67.36	
" "	21.82	49.54	
Staffordshire blue in mortar	22.43	69.22	701.1
Staffordshire blue in mortar	21.42	79.39	
Staffordshire blue in cement	29.45	84.47	
Staffordshire blue in cement	18.91	61.14	

Engineering points out that, "if these figures can be considered in any way generally applicable" (this sounds strangely in speaking of data supplied by a man of Prof. Unwin's reputation), they show "how inaccurate is the common assumption that the factor of safety for masonry is 15 or 20. It is, however, important to note that in no single instance did the piers in question fail by direct crushing, but always by shearing or tension. It is, of course, obvious that the vertical joints of a brickwork structure must always be points of weakness, as the cement does not set under conditions favorable to securing a good hold on the bricks, as in the bed joints, and in the piers in question failure always commenced at one of these vertical joints. In concrete, on the other hand, no such planes of weakness exist, whilst even in brickwork the conditions may be such as to prohibit failure from this cause. Still, experiments made in Austria on a brick arch of 75.5 feet span, having a rise of one-fifth and a thickness of 1.97 feet at crown and 3.6 feet at springings, resulted in its giving way when loaded on one-half the span with a load of about 27 tons per square foot. The dead weight of the arch itself must have given a stress of about 3.3 tons per square foot at the crown, which the test load would have increased to 6½ tons. In addition to this, the bending moment at the abutment, due to the unsymmetrical distribution of the test load, would, on the ordinary theory, have given rise to a stress of about 11 tons per square foot, thus making a total stress of some 14 tons per square foot on the most severely strained material at that point. In other parts of the arch—say, at a point about one-fifth the span from the crown—the calculated stress must have exceeded some 19 tons per square foot. Cracks were produced when the calculated tensile stress at the points of rupture reached from 3¾ to 5½ tons per square foot." An account of a discussion of Prof. Unwin's report is given in *The Journal of the Royal Institute of British Architects* (Dec. 31).

Electric Furnaces.

WHILE not believing that, where coal is employed for driving dynamos, the electric furnace can generally compete with furnaces directly heated by the combustion of coal, coke, or fuel gas, and, while admitting that producer gas, semi-water gas and water gas itself, have many advantages in common with electric furnaces for special heating where it is desirable to exclude dirt and other impurities from crucibles, Mr. F. H. Leeds, in *The Electrician* (Jan. 22), maintains that the electric furnace is economically comparable with fuel-heated furnaces, wherever cheap water power can be obtained. When the cleanliness, convenience, and ease of regulation of electric furnaces are taken into full consideration, it will be found that the electrical furnace has a future and a field in which it can compete directly with coal, even when the latter seems to occupy a perfectly unassailable position. It is because of the capacity to yield—so to speak—"pure unadulterated heat" that such a future may confidently be predicted for the electric furnace. There are many cases in mechanical construction, and in laboratory work, wherein the power to heat, while excluding air, oxygen, and other substances, is so invaluable that the smaller cost of fuel-heating is not worth a moment's consideration.

The Bertrand-Thiel Process.

THIS process, as studied *in situ* by Mr. Percy C. Gilchrist, is described by him in a paper read before the Middlesborough meeting (Dec. 14) of the Cleveland (Eng.) Institute of Engineers. From an advance proof of this paper, we are able here to set forth the main features of the process and some of its results. Descriptions of the process were given in a paper presented at the Colorado meeting of the American Institute of Mining Engineers (September, 1896), and in *The Iron and Coal Trades Review* (Oct. 27, 1896). The observations and conclusions of an expert eye-witness are of additional interest. The process is as follows:

A furnace having power to melt wrought iron, if that should be necessary, is employed. In one of the charges described in the paper the metal discharged from

this primary furnace was hot enough to freely volatilize. Brown smoke rose from the metal, as it ran down the landers, and this metallic vapor oxidized as soon as formed in the way that it does in the afterblast in the basic bessemer process, or in the acid process when a sufficient quantity of silicon is present. The work is divided between two, or a series of, furnaces. "Not less than three furnaces should be employed; two to superheat, desiliconize, partially dephosphorize, and decarbonize." Mr. Gilchrist thinks that "possibly six furnaces would be best, four to superheat molten metal from the blast furnace, one to desiliconize and dephosphorize to 0.10 per cent.," and one to still further desiliconize and dephosphorize to 0.01 per cent. These would be called "primary, secondary, and finishing furnaces," the metal issuing from the latter being ready for a casting. But he further says that good work is being done with only one primary and one finishing furnace. At Kladno, where the process was studied, the latter arrangement of furnaces is employed, but Mr. Gilchrist thinks that two primary furnaces and one finishing furnace would be a decided improvement. In such a case the metal from the primary furnaces would pass to the finishing furnace, which removes the remaining phosphorus and carbon, and the slag would be received by a bogey. When only two furnaces are used, "the ore and lime are added in the primary furnace with the charge (in the middle); in the finishing furnace, some ore and limestone are added with the charge (in the middle), the balance of ore and lime, if necessary, being added just before this furnace receives the metal from the primary furnace." Plans of this and of the series arrangement are presented with the paper, and a mass of tabulated data is supplied. A record of materials charged and products obtained in four separate charges is also given, together with details of times and manner of charging, very much too voluminous for reproduction here. The entire paper must be consulted for these particulars. An important deduction from these observations is the opinion that, if such a furnace as the primary furnace of the Bertrand-Thiel process "were employed as a feeder to the basic bessemer converter, no afterblow would be required." The metal from this primary furnace must be hot enough for treatment in the basic converter, since it emits copious vapors of iron. "If such a furnace be employed as a feeder to a second Siemens furnace, then this furnace would in less than one hour be ready for casting steel with traces of phosphorus and with any desired carbon whatever." The author also declares his opinion that a "commercial pig and ore direct process" is now available to the steel trade. The quality of the product is declared to be "equal to Swedish from any non-sulphurous pig"; a yield hither to unapproached is attained,and speed of working per furnace is increased. These statements come from an authoritative source, and lead to the belief that the Bertrand-Thiel process is destined to a future rivaling in usefulness other famous processes that have preceded it.

Balanced Slide-Valves for Locomotives.

WE have before noticed the present leaning toward features of American practice manifest in British railway engineering and management. There may well be reasons for some existing differences, but it cannot be that some things which have found favor among railway men in the United States and have there proved their value would not also be found serviceable on English railroads, notwithstanding that they have been, until recently, persistently ignored by our British cousins. Among the valued things pertaining to North American railroading is the balanced slide-valve, that form known as Richardson's having been fitted to a large number of locomotives, and used with good results. Speaking of this fact, *The Engineer* (Jan. 22) attempts to find a reason or reasons why the balanced slide-valve has found so little favor in England, and, after a review of the present status, in which the desirability of balancing is frankly conceded, recommends a reconsideration of the whole question. "The special feature of the English engine—inside cylinders—

places particular difficulties in the way. With seventeen-inch cylinders there is no room to spare for balancing devices, if the valve chest is placed between the cylinders. In the United States the inside-cylinder engine is unknown, and the valve chest on the top of an outside cylinder permits any balancing device to be adopted which is less high than the top of the chimney. In England, however, of late, the increase of pressure has once more directed attention to balancing, and we have piston valves under trial on more than one railroad." The Richardson valve is well spoken of; reasons are assigned why it has not succeeded in English practice, these reasons having been derived from an American source, but being seemingly approved as valid by our contemporary, which says: "We have been told by a competent United States engineer that we have failed in this country, because our workmanship has been too good; the rings have been fitted too tightly in the groove; but, besides this, English engineers have universally, or nearly so, used circular rings, whereas the Richardson valve is fitted with straight, separate, packing strips, which are a loose fit, and are made tight by the side pressure of the steam in the grooves. The success which has attended the use of the Richardson valve seems to substantiate the American argument, and justify the method of construction adopted. We have not summed up all the objections to balancing, when we have said that relief rings have not been successful. What will do very well in an engine which never runs many strokes without steam will not necessarily prove suitable to an engine which may have to make many hundreds of revolutions without steam. Unless some form of relief valve is fitted to the cylinders, a locomotive with balanced valves will, when running down an incline, draw in cinders from the smoke-box through the exhaust. The absence of such relief valves has more than once caused disaster. Their introduction, no doubt, increases complication. It might be possible to get over the difficulty by so coupling up the handle of the regulator with the cylinder drain-cocks that it would be impossible to close the regulator without opening the drain-cock, while those in turn could be opened by the driver when steam is on. Very little ingenuity would suffice for this. Possibly the drain cocks would have to be made a little larger than usual. But, after all, the introduction of a special relief-valve does not seem to be a very great evil. Such valves have been used on the Northeastern, the Midland, the Caledonian, and some other lines, without any particular trouble."

Sulphate of Ammonia.

ONE of the important by-products of the manufacture of gas is sulphate of ammonia. This is the most concentrated plant-food yet artificially produced, adding annually a large increase to the productiveness of the soil, and adding also to the revenues of the various gas undertakings throughout the world. Formerly the reputation of this fertilizer suffered from its imperfect manufacture. It affected crops very much as animals would be affected by a supply of poisoned food. In fact, it *was* in many instances *poisoned* plant-food. Now, it is, or can be, supplied free from the injurious substances that once contaminated it, and, as so supplied, it is claimed by Prof. H. H. Cousins of the South-Eastern Agricultural College, Wye, England (*Journal of Gas Lighting*, Jan. 26), it is the cheapest and most economical manure for furnishing nitrogen to plant growth. In view of the growing importance of this manufacture (it has increased in England since 1870 from 40,000 to upwards of 160,000 tons), Prof. Cousins commences, in the above-named issue of *The Journal of Gas Lighting*, an essay upon the subject, which will be printed serially. The first part deals with sources of supply, the injurious impurities still to be found in some samples of the salt, and of a ready means whereby almost any one can determine the quality of the commercial article. The chief impurities to be guarded against are the sulphocyanids and an excess of acid. Sixteen per cent. of free acid has been found in some of the English samples, and two per cent. is sufficient to render it destructively

injurious when applied to crops. The sulpho-cyanids should be completely removed, eight pounds per acre of this impurity being enough to destroy a growing crop, as asserted by the late Dr. Voelcker. Prof. Cousins therefore holds that the reputation and future sale of this salt must depend upon its sound manufacture, its purity, and its fertilizing value. The chemically pure salt should contain 25¾ per cent. of ammonia; the ordinary commercial product should contain from 24 to 24½ per cent. For fertilizing purposes, if the salt be free from the positively hurtful substances above named, it need not be pure. It may be tested as follows: "If heated to redness, it should volatilize completely. Adulteration with sand may be thus readily detected. To test for the presence of sulpho-cyanids, dissolve a dessert-spoonful of the salt in a little warm water, and add a few drops of the solution of chlorid of iron. Any red coloration is proof of the presence of poisonous sulpho-cyanids; and the sample is consequently dangerous to the health of plants. The remarkable variations in the color of the commercial article are due to slight traces of tarry matter, or to the quality of the acid employed in the manufacture. Vitriol derived from pyrites contains arsenic, and a yellow tint (due to sulphid of arsenic) is often observed in sulphate made from such acids. Blue or violet tints are due to traces of dyes produced from the tar products present."

Have We a Correct Theory of the Steam Engine?

NOTWITHSTANDING the facts that the world has been revolutionized by steam, that the ablest minds of the century have devoted themselves to investigating its properties, its behavior in steam engines, and the principles of heat engines, and that the conversion of heat into work is a process as familiar to most people as the cooking of food, some one occasionally springs upon us a new theory, or regales us with an account of experiments which completely unsettle our cherished convictions, and leave us in a state of mental confusion. We feel after something of this sort, much like the Frenchman who, after imbibing freely a particularly good vintage of Schloss Johannisberger, "did not know vere he vas any more." It is like getting up suddenly from a long-occupied stooping position, to rise from the persual of an editorial, "Expansion v. Throttling," in *The Engineer* (Jan. 22), and of the series of articles begun in the same issue, to which this editorial refers. It gives one, figuratively speaking, a rush of blood to the head. One feels like leaning up against something to think, like Mark Twain's fiery Arabian steed. The series of articles named illustrate and describe the experimental engines at the Durham College of Science, at Newcastle-upon-Tyne, England, with some results from the same. The first part describes the engines and their accessories; the second deals with the vertigo-producing results obtained by these remarkable machines. We opine that most people who have made steam a study will desire to correct their misapprehension by a persual of these articles. Next to knowing a great deal is it useful to know the limitations of our supposed knowledge. We begin to think, after reading the editorial in *The Engineer*, that these limitations are much greater than is generally supposed, and that neither it, we, or any one else knows anything about steam worth speaking of, not excluding even Prof. R. L. Weighton, M. A., vice-president, who contributes the article describing the Durham College Engines. Let the editorial speak for itself: "Professor Weighton is far too able and experienced an engineer to attempt to do more than one thing at a time. He impresses the lesson, indeed, so often forgotten, that, if more than one factor is varied, in any experiment, it is impossible to connect cause and effect in analyzing results. It is because this great truth is overlooked, disregarded, or undervalued that so many experiments with machinery of all kinds have been rendered abortive. But Prof. Weighton does not rest satisfied with calling attention to this truth. He goes on to say that the results of several individual trials are often found to be inconsistent and sometimes even contradictory.

We think that Prof. Weighton might have dwelt to advantage on this point. We have indirectly and directly insisted on it over and over again. We have felt that the paramount difficulty in the way of reformation of a theory of the steam engine lies in the contradictory results of experiments. Half a dozen theories have been prepared and put before the world as satisfactory explanations of all that does —and, we may add, does not—take place in a boiler, steam-pipe, cylinder, and condenser of a steam engine, and not one of these theories will satisfy all the conditions, or all the phenomena which are presented to the engineer or the physicist; and we find that what has apparently been proved up to the hilt by one set of experiments is equally proved not to be true by another set." It is asserted that Prof. Weighton's experiments are "no exception to the general rule."

This kind of thing makes one's head swim. But when this kind of thing is followed up by assertions that Prof. Weighton's experimental engines gave a difference of water-consumption of less than two pounds for expansions respectively of 17.4 times and 69.7 times; that, with the same ratios of expansion, different experiments gave notably different results; that in one case a notably better result was obtained by throttling to an average pressure than by an expansion of 19.8 times, and many more similarly puzzling results; when we read the deduction that these results indicate that "steam engines should be made as small as possible for their power,"—we begin to lose our faith in a supreme ruling power, to wonder what manner of machines Prof. Weighton has thus invented for the manufacture of riddles, and to marvel less at the work of that great genius, Grant Brambel, who has made a rotary engine of 300 h. p. to occupy a space of only 6″ × 18″, and proved its inestimable value by getting the assertion printed that he had sold the patents, with some important reservations, for some seven millions of dollars. In the practice of steam engineering we do not know where we are any more.

THE FRENCH AND GERMAN PRESS

The "Regulation" of the Iron Gates.

THE completion of the improvement works at the Iron Gates of the Danube, an undertaking begun by the Romans more than two thousand years ago and continued at irregular intervals ever since, marks an important engineering and commercial achievement. The *Zeitschrift d. Oesterr. Ing. u. Arch. Vereines*, in reviewing the valuable descriptive book of Béla v. Gonda, the Hungarian director of internal navigation, gives an excellent account of the work accomplished, and from this we make some extracts.

The principal point to be accomplished by the "regulation" of the river was the production of an unobstructed water-way from the city of Orsova through the rocky shallows of the Iron Gates and through the cataracts and whirlpools below, to the clear channel beyond, thus connecting the enormous traffic of the Danube, the great natural highway for the commerce of eastern Europe, with the outlet to the Black sea.

The general plan adopted consisted in the construction of a series of canals close to the right bank of the river, the canals enclosing a portion of the stream and providing an artificial channel. The rapid and irregular drop of the Danube has thus been converted into a gradual slope in the canals, so that the stream has practically been "graded" through the obstructions. It was decided that this channel should be not less than 60 meters wide, and should provide a depth at least 2 meters greater than the greatest recorded depth at Orsova,—the so-called "Orsovaer Pegel."

The actual work was commenced in the autumn of 1890, operations being started at the fourth cataract below the Iron Gates, the "Jucz-Katarakt"; here a canal 3,500 meters long was cut through the hard rock, enabling small boats at once to work their way up from Drenkova to Orsova. At the third cataract, called "Izlas-Tachtalia," the obstructions consisted of numerous groups of rocks, among which the water rushed in many leaps and eddies; here, owing to the rapid fall, a massive stone dam was necessary. This dam extends downwards diagonally across the river, being 6,200 meters long, and contains 500,000 cubic meters of rip-rap. At this cataract the river was formerly so shallow that navigation was utterly impracticable at low water for anything but rafts. The construction of this dam was, next to the blasting of the channel through the Iron Gates, the greatest work in the whole undertaking. The section of the canal at this point is 3,900 meters long.

The second cataract, "Kozla Dojke," is about five and a half miles farther up the river, and is passed by a canal enclosed between masonry walls for a length of 3,500 meters, while at the first cataract, just below the Iron Gates, there are 2,700 meters of canal to convert the very rapid fall of the stream into a navigable channel.

The Iron Gates themselves consist of five rocky dykes, extending across the river and reaching nearly to the surface of the water, the whole forming a sort of submarine plateau more than a mile in length, and over this natural dam the water rushes with great velocity. Some attempts were made to blast a channel through at this point in 1847-49, but a depth of only about four feet was secured. Since the peace of Paris in 1856, and especially since the Berlin congress in 1878, by which the international commissions were intrusted with the control of the river, and war-ships forbidden in the stream below the Iron Gates, the united interests of Austro-Hungary, Servia, and Roumania have urged the full completion of the channel, and this much-desired result has now been accomplished. Partly by damming the river, but largely by submarine blasting, the last canal has been cut through this series of natural obstructions, its length being 2,200 meters, width 60 meters, and depth full 3 meters.

This means that vessels of 2,500 tons displacement, and more than 8 feet of draft, can pass all the way up from the Black sea, past the four cataracts and through the Iron Gates, to the docks at Orsova.

Since the completion of the work, the passage up the stream through the canals has been made by unloaded tug-boats at the rate of 3¼ miles per hour, or, with heavy tows behind them, at a rate of more than half a mile per hour.

The formal opening of the canal by the emperor of Austria and king of Hungary, with the kings of Servia and Roumania, on September 27, 1896, was the great event of the Hungarian Millennial Celebration. The total cost of the present works, from 1890 to 1896, was 18,625,000 florins, or about $8,750,000.

The Sewage Plant at Budapest.

SINCE 1891 the city of Budapest has had under construction an important sewage-pumping plant, and the current number of the *Zeitschrift des Vereines Deutscher Ingenieure* contains a fully illustrated article describing the pumping machinery. The conditions of the problem were sufficiently varied to require an elastic plant, so to speak. When the level of the Danube is low, the sewage can be drained into the river by gravity, but for mean and high water pumping becomes necessary. At the same time it is required that the sewage shall be delivered at will to certain sewage farms nearly two miles distant, this latter duty involving an elevation of the liquid against the head of 16 meters. The ordinary service of the pumps, as demanded by the specifications, is the delivery of 1.8 cubic meters per second against a head of 5 meters; but, when the sewers are to be kept clear of storm water, the capacity is given as 27 cubic meters per second against a head of 1.55 meters.

In order to meet these varied requirements, the plant, as designed by Engineer Mich. v. Kájilinger, is divided into two distinct parts. One portion consists of six direct-connected centrifugal pumping engines, and the other of five horizontal plunger pumps, the former delivering only against the low head into the Danube, and the latter forcing against the high-pressure delivery to the sewage farms.

The centrifugal pumps are arranged in pairs, each pair being driven by a vertical compound engine placed between them. One pump is keyed fast to the shaft, and the other is connected by a Mechwart friction clutch, by which it can readily be thrown in or out of service. The diameter of the pump fans is 71 inches, and the engine cylinders are 15 inches and 23 inches in diameter, respectively, with a stroke of 21 inches, the speed ranging from 80 to 160 revolutions per minute, according to the requirements, and the boiler pressure being 110 pounds. The maximum capacity of each of the centrifugal pumps is 2.25 cubic meters per second, and, as each of the six engines drives two pumps, the maximum capacity of the plant for the low lift is 27 cubic meters, as required.

Some of the details of these engines are of interest, although in the main they do not show wide departures from general practice. The high-pressure cylinder is fitted with a Rider cut-off valve controlled by a Porter governor and dashpot, while the low-pressure cylinder has a slide-valve of the Trick or Allen type, neither valve being balanced. A special feature of the governor is the device by means of which the speed of the engines may be altered and controlled. The dashpot connected with the governor is supplied with oil at a constant pressure from a small pump, operated by an eccentric on the governor spindle. This oil flows through the dashpot cylinder at a rate controlled by an opening in a passage in the side, and returns to the pump again. By varying the size of this relief opening the pressure upon the dashpot piston is altered, which is equivalent to changing the weight on the governor, so that the speed of the engines can be changed at will from 80 to 160 revolutions, in order to meet the emergencies which may arise.

Tests of the engines and pumps showed a performance of about 35 pounds of steam per horse power of gross work in the form

of sewage raised,—this including all steam used for boiler feed and for condensing water. The efficiency, as shown by indicator cards, appears to have been about 17 to 18 pounds of steam per indicated horse power.

The high-pressure pumping engines consist each of a cross-compound Corliss engine, with cylinders 24.8 inches and 37.8 inches in diameter and a stroke of 47.4 inches, the piston rod of each cylinder being prolonged through the back cylinder head to form the pump rod. These engines are intended to run at a uniform speed of about twenty revolutions per minute, as they do not have to deal with the emergency flow.

The sewer system delivers into a large collecting sewer, which is situated at so high a level as to discharge into the river by gravity; and this collector is provided with ample overflow openings into a low-level collector leading to the pumps, which are thus called into use whenever the gravity discharge is impeded by high water. An independent feed collector leads to the high-service pumps, so that the sewage-farm supply is always provided for.

The Right of Employers to the Inventions of Employees.

THE question as to the ownership of inventions made by those who, at the time of invention, are in the employ of others is one upon which there has been some discussion in this country, although of late it has generally been settled by special contract made at the time of engagement.

An interesting article in *Glaser's Annalen* for January 15, by Dr. Jul. Lubszynski, discusses the status of the question in Germany, and we abstract from this his leading points.

The present patent law of Germany does not provide for the question, but the Austrian law states that workmen, employees, or government servants have the right to the inventions which they may make, unless there is a specific written contract to the contrary; and that rules of employment intended to take this right from the employee shall be void in law.

In practice, however, this law has not been found to cover all the conditions. In many cases a man is employed for the very purpose of developing and improving an appliance, and a contract in such a case should clearly not be necessary to secure to the employer the right to the product of his employee.

Again, the Austrian law makes no distinction between inventions made during the working-hours of the employer and those made in the private time of the employee. Upon this point there has been much discussion, and in Prussia there has been an attempt to give—for public work at least—a claim to the employer upon inventions pertaining to the work involved. As the law in Austria now stands, the employer has not even a shop right in inventions made during working-hours upon the special line of work in which the employee may be engaged.

In the line of suggestions for a proposed German enactment Dr. Lubszynski notes that there should be, if possible, some limit as to the nature of the invention, although he admits that it is not always easy to determine whether or no an invention comes within the special line of work in which the employee is regularly engaged. There should be also some consideration of the special circumstances in which the invention is made.

The precise moment at which an invention is made is not a matter which can be exactly determined. A man may conceive an idea outside of working-hours which clearly would never have occurred to him had he not been engaged upon the duties of the day, or, again, he may be engaged during his evening hours upon a totally different line of investigation, using his own materials and bearing all the expense himself, and yet make an important invention in that line during his employer's time. All these conditions should properly be taken into account in framing a law which shall be just to both parties alike, and, while the employee should not be deprived of the title to his invention, yet in many instances a limited right to the use of the invention should remain with the employer.

Proposed Electric Tramways in Paris.

THE question of increased facilities for local transportation in Paris is being agitated, especially in view of the anticipated requirements for the coming exposition, and *La Révue Technique*, for December 25, contains an outline of the scheme of MM. Cauderay and Renard for a system of electric tramways which shall meet all the demands of the situation. Apart from the local features of interest which the plans present, it is worthy of note that the scheme includes the idea of combining both underground and overhead trolleys with a storage system. Each car is to carry a storage battery, which may be charged at any time when in connection with a trolley wire, and the current from the storage battery is to be used to carry the car over that portion of the city in which no wire, either overhead or underground, is permitted. Wherever a subterranean conduit is permissible, it is to be constructed, while in the suburbs the overhead wire is contemplated. The practicability of the combination scheme is yet to be determined, but it is possible that in some such method the problem may be solved with justice to all concerned, not only in Paris, but on this side of the Atlantic as well.

The Le Chatelier Pyrometer.

THE difficulties in the way of the precise determination of high temperatures are well known, and, although the air thermometer has solved the problem for the most refined investigations, it is of necessity a laboratory instrument, unsuited for every-day use in manufacturing establishments.

The thermo-electric pyrometer of Le Chatelier, in its latest improved form, seems, however, to give greater promise of useful application than any other instrument yet devised for the purpose, and the following description of the apparatus is condensed from an article by Dr. Russner in the *Zeitschr. d. Oesterr. Ing. u. Arch. Vereines* for January 1.

Heretofore the fact that an electric current is developed when the junction of two dissimilar metals is warmed has been applied to the indication of very slight differences of temperature, as in the well-known thermo-electric plie. In the Le Chatelier pyrometer, however, the principle is modified by using two metals so nearly alike that a high temperature is needed to produce a moderate electromotive force. Briefly, the element consists of two wires, one of platinum and the other of an alloy of platinum and rhodium, each wire being about one meter long, and the two being fused together at one end. One of the wires is inserted in a porcelain tube open at both ends; the other is carried along just outside, so that the junction of the wires is at the end of the tube. This tube is then slipped into another tube, also of porcelain, but closed at one end, the junction of the wires being in the closed end, and the two free ends of the wires brought out to connections to a galvanometer.

The whole is enclosed in a protecting tube, open at the end, which is inserted into the furnace whose temperature is to be determined. Since both platinum and the platinum-rhodium alloy have very high fusing-points, the portion of the instrument which is exposed to the heat is able to stand very high temperatures, while the galvanometer upon which the readings are made may be at any distance from the furnace, either in the office or in any desired part of the establishment.

Each pyrometer is calibrated by comparison with an air thermometer, and it has been found that an alloy of 90 per cent. platinum and 10 per cent. rhodium for one wire, and pure platinum for the other, give an electromotive force nearly proportional to the temperature, so that a temperature of 1,800 degrees C. produces 1,800 microvolts, etc. This is almost exactly true for temperatures of 700° C. and above. An alloy of 85 per cent. platinum and 15 per cent. rhodium produces a feebler current, an electromotive force of 800 microvolts being produced by a temperature of about 1,650° C.

The principal difficulty seems to consist in the production of a definite alloy of platinum and rhodium, on account of the high fusing-point, but the firm of Heräus

at Hanau a. Main has now put on the market platinum wire containing 10 per cent. of rhodium, well adapted for this use. Although any galvanometer may be adapted for use with this form of pyrometer, a special instrument on the Deprez-d'Arsonval principle is furnished by the makers of the pyrometer, Messrs. Keiser & Schmidt of Berlin, the whole design of the apparatus having been made by Dr. Holborn and Dr. Wien.

Experimental comparisons with the air thermometer have shown that the Le Chatelier pyrometer will determine temperatures within an error of ± 5° C. for 1,000°. One of the instruments was subjected to the continuous action of a Siemens regenerative furnace in a glass-works for 3½ months without injury, following the variations of temperature between 1,100° and 1,600° C.; when re-compared with the air thermometer, the zero was found to be unchanged.

In this connection the following determinations of fusing-points made by the Le Chatelier pyrometer and those of previous observers are given, those of Holborn and Wien having been made with the new pyrometer.

	Violle.	Barus.	Holborn & Wien.
Silver	954°C	986°C	971°C
Gold	1,045°	1,091°	1,072°
Copper	1,054°	1,096°	1,082°
Nickel	———	1,476°	1,484°
Palladium	1,500°	1,585°	1,587°
Platinum	1,775°	1,757°	1,780°

The Senegal-Niger Railway.

THE return of the Hourst Niger expedition, and the account of its successful navigation down the Niger from Timbuktu to its mouth, give added interest to the description of the Senegal-Niger Railway in the *Revue du Génie Militaire*.

The Senegal river flows into the Atlantic at the extreme western point of Africa, passing through the French colony of Senegal, the town of St. Louis being at its mouth. The river is navigable as far up as Kayes, about four hundred miles from the coast; while about one hundred miles further back it divides into its two sources, the Bahfing and the Bakhoy, which originate in the mountains of the Soudan.

The Niger has its rise in the same mountains, but, instead of flowing westward, it takes the other side of the watershed, and, after traversing about seven hundred and fifty miles of territory to the north-east, it turns southward and empties into the Gulf of Guinea.

The plateau, which is reached by the navigable waters of both rivers, is less than three thousand feet above sea-level, and for many years the idea, which originated with General Faidherbe, of connecting the upper portion of the two rivers by a railroad has been a favorite one with the French government.

A portion of the road has now been built, and the account of the work and its difficulties is especially interesting at the present time. In the preliminary operations there were many set-backs, due to unfavorable weather, sickness, and other delays, but by 1888 more than eighty miles, from Kayes to Bafoulabé, had been constructed after a fashion, including the viaduct bridge at Galougo.

Much of this work, however, was imperfect, being ballasted only where local rock was available, and in the rainy season many washouts occurred. In 1892 the work was turned over to a detachment of French army engineers, and the road has been actively pushed since that time. The old work has been reballasted and repaired, and the extension of the line toward Bammako on the Niger has been surveyed and partially constructed. While about two-thirds of the road remains to be built, there is every reason to believe that its completion will be rapidly pushed through, and the fact that the portion already built is nearly paying its operating expenses is in itself most encouraging.

The completion of the line will open a commercial route through the richest portion of western Africa, the combined length of the railroad and waterways being nearly two thousand miles, giving access to the city of Timbuktu and complete internal connection from the west coast to the Gulf of Guinea. At the present time there is telegraph communication from Kayes to St. Louis at the mouth of the Senegal, and a cable from St. Louis to

Europe by way of Teneriffe, so that this line places the heart of western Africa in direct communication with the civilized world.

When it is considered that this railroad has been planned and already partly constructed through a country in large part unknown and only partially subdued, and that the difficulties of an insalubrious climate and native opposition have been successfully overcome, we cannot but admire the energy and persistence of Messrs. Marmier and Joffre, the engineers by whom the plans of General Faidherbe have thus far been realized.

The Sanitation of Steamships.

A VERY valuable series of articles by Herr Carl Busley is appearing in the *Zeitschrift des Vereines Deutscher Ingenieure* upon the sanitary arrangements of modern steam vessels, and the high reputation and wide experience of the author render his opinions important.

Beginning with the subject of fresh air, the various systems of ventilation are described, with plans of the arrangements of windsails, air ducts, exhausters, fans, and the like, details of the various methods being given. In some cases forced ventilation is used, and in others only exhaust fans are employed, but Herr Busley prefers a combination of the two, the fresh air being delivered under pressure to the lowest and most distant points of the vessel, while the foul air is drawn off above. The system, as applied to the German cruiser, "Aegir," is shown as an example of this double system.

The question of drinking water is next taken up, and the various forms of filters, distilling apparatus, etc., are illustrated and described. With these are also given the arrangements for the supply of hot and cold water to the innumerable washstands, as well as the bath-rooms; and, although the especial plans shown are those of a modern ship of war, yet the details are practically those adapted for passenger-steamers as well, many of them being those used by the vessels of the North German Lloyd Company. The question of the discharge of waste water and the arrangement of water-closets is given space in proportion to the importance of the subject, and articles on lighting and warming will follow.

While these matters are even more important on shipboard than ashore, they have been given little or no consideration in the treatises on ship construction, and, from the nature of the case, methods which are satisfactory in hotels and residences cannot always be used on a great vessel; hence these articles by the director of the great yard at Kiel are a welcome addition to marine literature.

The Danube-Moldau-Elbe Canal.

THE project of a canal to unite the navigation of the Danube with that of the Elbe through the Moldau has been a subject of many plans and discussions, in times past, but it now bids fair to become a reality, judging from the plan of the Austrian government, described in the January issue of the *Oesterr. Monastchr. f. d. oeffent. Baudienst.*

The first official action leading to the present scheme was the appointment in 1879 of a commission, which investigated the problem at length and reported in the spring of 1884 upon the feasibility of the work, as well as upon the concurrence of Bohemia in the political questions involved.

This was followed by a competition for the best plan for the execution of the work, including the selection of route and provision for overcoming the differences of elevation and other engineering problems. The commission having charge of the competition issued, in May, 1892, the conditions within which the plans were to be prepared, and the result has been the submission of three schemes, by as many different engineering firms.

It is contemplated to build the canal from the Danube, at or near Vienna, to Budweis on the Moldau, the latter river giving navigable connection with the Elbe and the North sea. This gives a length of from 100 to 125 miles, depending upon the choice of route, while the difference in elevation between Vienna and Budweis is more than 600 feet, with an in-

tervening elevation of about 1,200 feet to be surmounted. The canal is required to be 98 feet wide at the surface and 60 feet at the bottom, the depth to be about 7 feet, with provision on all bridges for deepening to 8 feet, the canal being intended to receive vessels of 200 feet in length and 25 feet in breadth, at the water line, with a draft of 5 feet 9 inches.

The work also includes the "canalization" of the Moldau from Budweis, and the Elbe from Melnik, so as to provide a channel of a minimum depth of 7 feet, with locks arranged to permit continuous navigation, and weirs to provide for the passage of rafts.

The minimum width of any tunnel is to be 35 feet, with a headway of 20 feet above the surface of the water.

The plans submitted follow different routes, and the methods by which the different engineers propose to solve the difficult problems involved are of interest.

The firm of Hallier & Dietz-Monin proposes to overcome the height of nearly 1,250 feet which their route involves, by means of seven inclined planes with slopes of 40 to 60 per cent. This plan involves a canal 181 kilometers long and a cost of $30,000,000, or about $273,000 per mile.

The second plan—that of Herr Gröger—is somewhat shorter, as it leaves the Danube about 50 kilometers above Vienna. It involves the use of a combined system of locks and inclined planes, the estimated cost being about $26,000,000,—about the same per mile as that contemplated by the previous plan. This scheme includes two tunnels 6,000 and 8,000 feet long, respectively.

The third plan—that of the firm of Lanna & Vering—offers a lock system, and includes one tunnel of 6,000 feet in length and five smaller ones of 300 to 3,000 feet. This canal would be 130 miles in length, and the estimated cost is $28,000,000, or about $215,000 per mile.

All of these plans include elaborate systems of reservoirs for the supply of water, it being estimated that a storage supply of about 25,000,000 cubic meters will be required.

Taking into account the cost of improving the rivers, it is estimated that the entire cost of a water communication between Vienna and the North sea will be about $47,000,000.

The manner in which this sum is to be raised does not yet appear, but it is intimated that the project should take on the character of an international work, constructed and maintained by Austria, Prussia, Bohemia, Saxony, and, indeed, the "united States of Europe."

Carbons for Electrolysis.

THE extension of electrolytic processes in industrial chemistry has created a demand for terminals which shall be inexpensive and permanent, and numerous patents in this line have been taken out, especially in connection with the electrolytic production of the alkaline chlorids.

Dr. Albert Lessing describes, in the *Elektrochemische Zeitschrift*, some of the objections to those in use, and claims to have overcome the difficulties. The ideal anode should possess the qualities of permanence, small volume, and moderate expense. The first two properties are possessed by platinum, but its high cost is prohibitive for use in large operations, such as commercial reasons demand. Carbon has been used as the most available material, but in its present forms is not free from objection.

Gas carbon is not available in large sheets, such as are commercially required, and hence these have been made of powdered coke, baked with a cementing material in the same manner as electric-light carbons are made. Such carbon plates, however, are not permanent, but soon become disintegrated by the action of the solutions, and especially by the action of the liberated gases. This disintegration is rather a mechanical than a chemical action, and the slightest porosity or the finest crack gives the gases a chance to enter, after which the carbon flakes off in layers and crumbles away, fouling the bath and interfering with the work.

Dr. Lessing claims now to have solved the problem, after much experimenting, by producing carbon sheets entirely homogeneous and free from cracks, by a fusing

process which not only insures the permanence of the sheet, but also increases its conductivity. The new product is said to be harder than steel, readily scratching glass and proof against the emery wheel, and possesses a metallic ring which testifies to its homogeneity. If these claims are maintained, and the prepared carbon can be produced at a reasonable price, it should soon be on the market for many other uses as well as the one for which it was originally produced.

Electric Traction in Germany.

ELECTRIC tramways are making rapid progress in Germany, and a review of recent installations is given by Ober-Ingenieur von Krenn in the January issue of the *Oesterr. Monatschrift f. d. Oeffentlichen Baudienst.*

The overhead trolley is making its way rapidly, and is now in use not only in Remschied, Barmen, Hanover, and Hamburg, but also in Dresden, Leipzig, and Berlin. In the central portion of Dresden, however, the unsightly trolley wire has not yet been admitted, and the combination of overhead wire and storage-battery is used, the batteries being used for motive power in the section where no wires are permitted.

In Berlin two underground installations are being constructed, one by Siemens & Halske, and the other by the Union Elektricitäts Gesellschaft, and it is understood that several overhead systems are to be replaced by underground conductors.

The speeds in use are about the same as those in this country, the limit in Dresden being eighteen kilometers an hour. Trailer cars are in general use, although most of them have no provision for lighting or braking. In Berlin speeds of fifteen miles are permitted, and in other cities the speeds are regulated according to the part of the city traversed. The smoking-car problem is solved by limiting smokers to the trailers. Germany, like France, seems to be endeavoring to obtain the advantages of electric traction without unnecessary unsightliness, while, as yet, we have to accept all the ugliness or go without the convenience.

The Scandinavian Exposition.

IN 1866 the first Scandinavian exposition was held at Stockholm, since which time there have been two industrial exhibitions, both held at Copenhagen—one in 1872 and the other in 1888. This year there is to be one again at Stockholm, and it is expected that there will be a most interesting display of the special industries of Norway, Sweden, and Denmark.

Since the exhibition of 1866 the development of the mining and lumbering interests of Sweden has been great. Today 25,000 men are employed in the lumber trade alone, the exports of unworked timber amounting to $31,000,000, and of worked lumber to $5,400,000 a year, while in 1866 the total lumber trade hardly reached $8,500,000.

In the thirty years the production of iron has quadrupled, and the output of steel has risen from 7,000 tons in 1866 to 170,000 tons per year, while the railway mileage has increased from 930 miles in 1866 to 6,200 at the present time.

In view of these conditions, and other branches of trade showing a like increase, a noteworthy exposition of Swedish industries may be expected.

The Bridge of the Paris Exposition.

THE Pont Alexandre III, to which reference was made last month, has been under discussion by the *Société des Ingénieurs Civils de France*, especially with regard to the obstruction which a bridge built after the adopted design will offer to navigation. The adoption of a single arch brings the headway near the banks too low to permit safe navigation beneath, especially since the bend in the river at the location of the bridge throws the channel close to the right bank.

The following points were made,—that the pier on the right bank should be carried back far enough to conform to the requirements of the commission of 1896, and thus not prevent access to the river bank, and that the arch should be raised sufficiently to give a passage not less than 5 meters high and 60 meters wide at all conditions of the river.

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Am. Engineer and Railroad Journal. *m.* $2. N.Y.
American Gas Light Journal. *w.* $3. New York.
American Geologist. *m.* $3.50. Minneapolis.
American Journal of Science. *m.* $6. New Haven.
American Journal of Sociology. *b-m.* $2 Chicago.
American Machinist. *w.* $3. New York.
American Magazine of Civics. *m.* $3. New York.
Am. Manufacturer and Iron World. *w.* $4. Pittsburg.
American Shipbuilder. *w.* $2. New York.
Am. Soc. of Irrigation Engineers. *qr.* $4. Denver.
Am. Soc. of Mechanical Engineers. *m.* New York.
Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
Annales des Ponts et Chaussées. *m.* 31 francs. Paris.
Architect, The. *w.* 26*s.* London.
Architectural Record. *q.* $1. New York.
Architectural Review. *s-q.* $5. Boston.
Architecture and Building. *w.* $.4 New York.
Architektonische Rundschau. *m.* 18 marks. Stuttgart.
Arena, The *m.*, $5. Boston.
Australian Mining Standard. *w.* 30*s.* Sydney.
Baker's Railway Magazine. *m.* $2. N. Y.
Bankers' Magazine. *m.* $5. New York.
Bankers' Magazine. *m.* 18*s.* London.
Bankers' Magazine of Australia. *m.* $3. Melbourne.
Berg- und Hüttenmännische Zeitung. *w.* 26 marks. Berlin
Board of Trade Journal. *m.* 6*s.* London.
Boston Journal of Commerce. *w.* $3. Boston.
Bradstreet's. *w.* $5. New York.
Brick Builder, The *m.* $2.50. Boston.
British Architect, The. *w.* 23*s.* 8*d.* London.
Builder, The. *w.* 26*s.* London.
Bulletin Am. Iron and Steel Asso. *w.* $4. Phila.
Bulletin of the Univ. of Wisconsin, Madison.
California Architect. *m.* $3. San Francisco.
Canadian Architect. *m.* $2. Toronto.
Canadian Electrical News. *m.* $1. Toronto.
Canadian Engineer. *m.* $1. Montreal.
Canadian Mining Review. *m.* $3. Ottawa.
Century Magazine. *m.* $4. New York.
Chautauquan, The *m.* $2. Meadville, Pa.
Colliery Engineer. *m.* $2. Scranton, Pa.
Colliery Guardian. *w.* 27*s.* 6*d.* London.
Compressed Air. *m.* $1. New York.
Contemporary Review. *m.* $4.50. London
Deutsche Bauzeitung. *b-w.* 15 marks. Berlin.
Dingler's Polytechnisches Journal. *w.* 43.60 marks. Stuttgart.
Domestic Engineering. *m.* $2. Chicago
Electrical Engineer. *w.* 19*s.* 6*d.* London.
Electrical Engineer. *w.* $3. New York
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Electrical Review. *w.* 21*s.* 8*d.* London.
Electrical Review. *w.* $3. New York.
Electrical World. *w.* $3. New York.
Electrician. *w.* 24*s.* London.
Electricity. *w.* $2.50. New York.
Electricity. *w.* 7*s.* 6*d.* London.
Elektrochemische Rundschau. *b-m.* 9.50 marks. Frankfurt.
Elektrotechnisches Zeitschrift. *m.* 18.40 marks. Berlin.
Elektrotechnisches Echo. *w.* 12 marks. Magdeburg.
Elektrotechniker. *b-m.* 12 marks. Vienna.
Elektrotechnischer Anzeiger. *s-w.* 10 marks. Berlin.
Elektrotechnische Zeitschrift. *w.* 25 marks. Berlin.
Engineer, The. *s-m.* $2. New York.
Engineer, The. *w.* 36*s.* London.

Engineers' Gazette. *m.* 8*s* London.
Engineering. *w.* 36*s.* London.
Engineering Assns. of the South. Nashville.
Engineering and Mining Journal. *w.* $5. N. Y.
Engineering Magazine. *m.* $3. New York.
Engineering-Mechanics. *m.* $2. Phila.
Engineering News. *w.* $5. New York.
Engineering Record. *w.* $5. New York.
Engineering Review. *m.* 7*s.* London.
Eng. Soc. of the School of Prac. Sci. Toronto.
Eng. Soc. of Western Penn'a. *m.* $7. Pittsburg.
Fire and Water. *w.* $3. New York.
Forester, The. *bi-m.* 50 cts. May's Landing, N.J.
Fortnightly Review. *m.* $4.50. London.
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Gas Engineers' Mag. *m.* 6*s.* 6*d.* Birmingham.
Gas World, The. *w.* 13*s.* London.
Glasers Annalen für Gewerbe und Bauwesen. *s-m.* 20 marks. Berlin.
Gunton's Magazine. *m.* $2. New York.
Heating and Ventilation. *m.* $1. New York.
Ill. Carpenter and Builder. *w.* 8*s.* 8*d.* London.
India Rubber World. *m.* $3. New York.
Indian and Eastern Engineer. *w.* 20 Rs. Calcutta.
Indian Engineering. *w.* 18 Rs. Calcutta.
Industries and Iron. *w.* £1. London.
Inland Architect. *m.* $5. Chicago.
Iron Age, The. *w.* $4.50. New York.
Iron and Coal Trade Review. *w.* 30*s.* 4*d.* London
Iron & Steel Trades' Journal. *w.* 25*s.* London
Iron Trade Review. *w.* $3. Cleveland.
Jour. Am. Soc. Naval Engineers. *qr.* $5. Wash.
Journal Assoc. Eng. Society. *m.* $5. St. Louis.
Journal Franklin Institute. *m.* $5. Phila.
Journal of Gas Lighting. *w.* London.
Jour. N. E. Waterw. Assoc. *q.* $2. New London.
Journal Political Economy. *q.* $3. Chicago.
Journal Royal Inst. of Brit. Arch. *s-q.* 6*s.* London
Journal of the Society of Arts. *w.* London.
Journal of the Western Society of Engineers. *b-m.* $2. Chicago.
Kansas University Quarterly. *qr.* $2. Lawrence, Kan.
La Nature. *w.* 24.50 francs. Paris.
La Révue Technique. *b-m.* 28 francs. Paris.
L'Eclairage Electrique. 60 fr. Paris.
Le Génie Civil. *w.* 45 fr. Paris.
L'Electricien. *w.* 25 fr. Paris.
Le Moniteur des Architectes. *m.* 33 francs. Paris.
Le Moniteur Industriel. *w.* 40 francs. Paris.
Locomotive Engineering. *m.* $2. New York.
Machinery *m.* $1. New York.
Machinery. *m.* 9*s.* London.
Manufacturer's Record. *w.* $4. Baltimore.
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McClure's Magazine. *m.* $1. New York.
Metal Worker. *w.* $2. New York.
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Monatsschrift des Württ. Vereines für Baukunde. 10 parts yearly. 3 marks. Stuttgart.
Municipal Engineering. *m.* $2. Indianapolis.
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Nature. *w.* $7. London.
New Science Review, The. *qr.* $2. New York.
Nineteenth Century. *m.* $4.50. London
North American Review. *m.* $5. New York
Oesterreichische Monatsschrift für den Oeffentlichen Baudienst. *m.* 14 marks. Vienna.
Physical Review, The. *b-m.* $3. New York.
Plumber and Decorator. *m.* 6*s.* 6*d.* London
Popular Science Monthly. *m.* $5. New York
Power. *m.* $1. New York.
Practical Engineer. *w.* 10*s.* London.
Proceedings Engineer's Club. *q.* $2. Phila.
Proceedings of Central Railway Club.
Pro. of Purdue Soc. of Civ. Engs. *yr.* 50 cts. La Fayette, Ind.
Progressive Age. *s-m.* $3. New York.
Railroad Car Journal. *m.* $1. New York.
Railroad Gazette. *w.* $4.20. New York.
Railway Age. *w.* $4. Chicago.
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Railway Press, The. *m.* 7*s.* London.
Railway Review. *w.* $4. Chicago.
Railway World. *m.* 5*s.* London.
Review of Reviews. *m.* $2.50. New York.
Safety Valve. *m.* $1. New York.
Sanitarian. *m.* $4. Brooklyn.
Sanitary Plumber. *s-m.* $2. New York.
Sanitary Record. *m.* 10*s.* London.
School of Mines Quarterly. $2. New York.
Schweitzerisches Bauwesen. *w.* 20 marks. Zurich.
Science. *w.* $5. Lancaster, Pa.
Scientific American. *w.* $3. New York.
Scientific Am. Supplement. *w.* $5. New York.
Scientific Machinist. *s-m.* $1.50. Cleveland, O.
Scribner's Magazine. *m.* $3. New York.
Seaboard. *w.* $2. New York.
Sibley Journal of Eng. *m.* $2. Ithaca, N. Y.
Southern Architect. *m.* $2. Atlanta.
Stahl und Eisen. *s-m.* 20 marks. Dusseldorf.
Stationary Engineer. *m.* $1. Chicago.
Steamship. *m.* Leith, Scotland.
Stevens' Indicator. *qr.* $1.50. Hoboken.
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Street Railway Journal. *m.* $4. New York.
Street Railway Review. *m.* $2. Chicago.
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Trans. Am. Ins. Electrical Eng. *m.* $5. N. Y.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Civil Engineers. *m.* $10. New York
Transport. *w.* £1. 5*s.* London.
Western Electrician. *w.* $3. Chicago.
Western Railway Club, Pro. Chicago.
Wiener Bauindustrie Zeitung. *w.* 27 marks. Vienna.
Wisconsin Engineer. *qr.* $1.50. Madison, Wis.
Yale Scientific Monthly, The. *m.* $2.50 New Haven.
Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines. *w.* 53 marks. Vienna.
Zeitschrift des Vereines Deutscher Ingenieure. *w.* 32 marks. Berlin.
Zeitschrift für Elektrochemie. *s-m.* 16 marks. Halle, a. S.
Zeitschrift für Elektrotechnik. *s-m.* 16 marks. Halle a. S.
Zeitschrift für Instrumentenkunde. *m.* 20 marks. Berlin.

ARCHITECTURE AND BUILDING.

CONSTRUCTION AND DESIGN.

ASYMMETRY in Medieval Italian Churches, Constructive. William H. Goodyear (The subject is confined to the cases of constructed asymmetry in the dimensions of arcades and arches, in oblique horizontal lines and in ground plans. Ill. 7,000 w.) Arch Rec—Jan., March, 1897. Serial, first part. No. 10,634. 30 cts.

CHURCH, Plans for a Greek Catholic—at Sereth (Project für eine griechisch-katholische Kirche in Sereth) (Brief description and four sheets of drawings. 500 w.) Oesterr Monatschr f. d. Oeffent Baudienst—Jan., 1897. No. 10,778. 30 cts.

COTTAGE Architecture, Notes On. Ralph Nevill (Discusses the subject under the heads of accommodation, style, plan and material. 7,000 w.) Jour Roy Inst of Brit Archts—Dec. 31, 1896. No. 10,673. 30 cts.

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FLOOR Construction in New York City, Fireproof (Presents and discusses facts collected on this subject, and the New York building law. 5,000 w.) Eng News—Feb. 4, 1897. No. 10,902. 15 cts.

FOUNDATIONS, The Distribution of Pressure in Foundations (Ueber die Bedingungen einer gleichformigen Druckvertheilung in den Fundamenten.) A further discussion, by Rudolf Mayer, of the conditions existing between depth, load and cohesion for the uniform distribution of pressure. 3,000 w.) Zeitschr d Oesterr Ing u Arch Vereines—Jan. 15, 1897. No. 10,755. 15 cts.

GOVERNMENT BUILDINGS, The Architecture of Our. William Martin Aiken (An exposition of the duties and methods of the supervising architect of the United States. Ill. 3,100 w.) Eng Mag—Feb., 1897. No. 10,302. 30 cts.

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LINCOLN Cathedral (Illustrated description with history. 2,000 w.) Arch, Lond—Jan. 1, 1897. No. 10,384. 30 cts.

MACHINERY HALL at the Swiss Exposition at Geneva, The (Describes the cantilever system of roof trusses. The plan is chiefly remarkable for its economy in construction and its lightness. 350 w.) Eng News—Jan. 21, 1897. No. 10,556. 15 cts.

MONOLITHIC Churches of Lalibela (Abyssinia), The. From La Nature (Illustrated description of these curious churches. 1,000 w.) Sci Am Sup—Jan. 16, 1897. No. 10,439. 15 cts.

NATIONAL Architecture, Two Interpreters of. Henry Van Brunt (A comparison of the work and career of two eminent architects, John Wellborn Root and Charles Bulfinch, as set forth in recent publications, with much interesting information in relation to American architecture. 7,500 w.) Atlantic M—Feb., 1897. No. 10,577. 35 cts.

PETERBOROUGH Cathedral (Preliminary specification written at the request of the Society of Antiquaries, to explain what would be necessary in works of repair to secure a part of the fabric of the portico from further dilapidation, and to secure its present condition and appearance. 5,700 w.) Arch, Lond—Jan. 15, 1897. No. 10,607. 30 cts.

SANGER Hall, Philadelphia (Illustrated description of the design and construction of a large temporary auditorium. 800 w.) Eng Rec—Jan. 9, 1897. No. 10,336. 15 cts.

SPECIFICATIONS (The first of a series of articles for students giving directions and explaining the object and uses of the document. 2,000 w.) Builder—Jan. 2,

1897. Serial, first part. No. 10,390. 30 cts.

STYLE of Architecture, The Possibility of a New. D. B. Dick (Read before the Ontario Assn. of Archts. An interesting study of style in architecture; the great principles and the elements of architectural construction, and the outlook for future formation of a new style. 8,500 w.) Can Arch—Jan., 1897. No. 10,614. 30 cts.

WALHALLA of Ratisbon, The (Illustrated description of a German Temple of Fame, which is a costly reproduction of the Parthenon at Athens. 600 w.) Sci Am—Jan. 23, 1897. No. 10,535. 15 cts.

HEATING AND VENTILATION.

BOILER Progress. H. J. Barron (Inquiry with view of finding out which is the most practical type for ordinary steam-heating at pressures under fifteen pounds, from the contractor's standpoint. 3,000 w.) Dom Engng—Jan., 1897. No. 10,747. 30 cts.

CENTRAL PLANTS, Warming Office Buildings and Residences from (Notes concerning the design and management of the Harrisburg (Pa.) Steam Heat and Power Co., describing the distribution of steam for the warming of neighboring buildings from a central plant. 1,100 w.) Eng Rec—Jan. 23, 1897. No. 10,600. 15 cts.

DIRECT RADIATION, Methods of Proportioning. R. C. Carpenter (Read at meeting of Am. Soc. of Heat and Ven. Engs. Calls attention to the methods which have been proposed in the past and to a modified method resulting from experiment, which the writer believes to be at least worthy the trial of all heating engineers. 2,500 w.) Met Work—Jan. 30, 1897. No. 10,687. 15 cts.

FAN CAPACITY, Determination of (Explains the method of determining the fan capacity required when the calculations are based merely upon the times of air change; the system generally adopted for factory and similar work. 1,400 w.) Heat & Ven—Jan. 15, 1897. No. 10,517. 15 cts.

FURNACE Heating (Examines the causes why they sometimes fail to heat. 1,200 w.) Dom Engng—Jan., 1897. Serial, first part. No. 10,748. 30 cts.

HEATING and Lighting Plant, An Interesting Central (Illustrated description of the arrangements for heating and lighting a group of buildings at Garden City, Long Island, N. Y. 1,600 w.) Eng Rec—Feb. 6, 1897. No. 10,927. 15 cts.

HEATING AND VENTILATION of Public Buildings, Combined. J. D. Sutcliffe (Read before the Manchester Soc. of Architects. Part first discusses warming by direct and indirect radiation and gives reasons for adopting the warm air system. 3,400 w.) Heat & Ven—Jan. 15, 1897. Serial, first part. No. 10,518. 15 cts.

HEATING AND VENTILATION of the West Side Branch Y. M. C. A. F. R. Harris (Illustrated description. 1,500 w.) Heat & Ven—Jan. 15, 1897. No. 10,516. 15 cts.

HOT WATER Circulation; Fundamental Principles of—on Which the Various Water-Heating Systems Depend for Success. James J. Lawler (The special object is to show these fundamental principles of circulation in a plain, simple way, and lead step by step to the most complicated systems. Ill. 1,600 w.) San Plumb—Jan. 15, 1897. Serial, first part. No. 10,478. 15 cts.

HOT WATER Heating Apparatus, A Novel Steam (The novelty of the system consists in the entire omission of air valves and air-valve piping and also the possibility of controlling the temperature of the coils to suit the weather. Ill. 900 w.) Eng Rec—Jan. 23, 1897. No. 10,601. 15 cts.

HOT WATER Heating Apparatus, Arrangement of Mains in. W. M. Mackay (Read at meeting of Am. Soc. of Heat. & Ven. Engs. Describes earlier systems and gives information from the writer's experience and observation. 2,200 w.) Met Work—Jan. 30, 1897. No. 10,685. 15 cts.

HOT WATER Plant near Philadelphia, A Recent (Illustrated description of the plant in residence of Mr. Cyrus H. K. Curtis, at Wyncote, Pa. 600 w.) Eng Rec—Jan. 9, 1897. No. 10,337. 15 cts.

STEAM HEATING Plants, Defective. W. H. Wakeman (Calls attention to some of the defects that cause a steam plant to work in an unsatisfactory manner. 1,500 w.) Mach—Feb., 1897. No. 10,866. 15 cts.

STEAM PLANT, Boston Public Library and Its. A. J. Guernsey (Brief account of the working equipment, ventilation, lighting, steam plant, boilers, &c. 2,200 w.) Safety V—Jan., 1897. No. 10,489. 15 cts.

VOLUME of Air Passing Through a Register per Minute, Determining the. J. H. Kinealy (Read at meeting of the Am. Soc. of Heat. & Ven. Engs. Gives methods for determining the velocity of the air, tests and results of experiments. 2,400 w.) Met Work—Jan. 30, 1897. No. 10,686. 15 cts.

LANDSCAPE GARDENING.

IMPROVEMENT Societies, Village. Mary Caroline Robbins (Reviews the work and notes what has been accomplished, shows in how many directions the art is being applied, its effect on the value of property and the character of the community. 7,500 w.) Atlantic M—Feb., 1897. No. 10,576. 35 cts.

NORTH WOODS, The (Editorial presenting the importance of New York

State owning this region, with extract from Gov. Black's message. 1,200 w.) Gar and For—Jan. 20, 1897. No. 10,528. 15 cts.

PARK-Making as a National Art. Mary Caroline Robbins (Brief outline of the work in this country, with typical examples of the work and of the artistic skill of Frederick Law Olmsted. The importance and the necessity of proper maintenance, with the unlimited possibilities of the art. 7,000 w.) Atlantic M—Jan., 1897. No. 10,575. 35 cts.

PARK-Making as a National Art (Editorial review of an article by Mrs. M. C. Robbins, published in the Atlantic Monthly for Jan. 1,400 w.) Gar & For—Jan. 13, 1897. No. 10,416. 15 cts.

PLEASURE-GROUNDS, The Need of More Public (Editorial urging that some attention be given to this need of the people, both in city and country. 1,500 w.) Gar & For—Jan. 27, 1897. No. 10,645. 15 cts.

WATERING PLACE, The Springs of Dorna-Watra (Die Curhaus Anlage in Dorna-Watra.) (An illustrated description of the baths and casino at Dorna-Watra, in the Carpathians. 1 plate of architectural plans. 2,500 w.) Zeitschr d Oesterr Ing u Arch Vereines—Jan. 15, 1897. No. 10,754. 15 cts.

PLUMBING AND GAS FITTING.

COMPARISON, A—F. Handover (Views on English and American plumbing. 650 w.) Dom Engng—Jan., 1897. No. 10,745. 30 cts.

GAS CONTROL from Meter to Burner. D. Macfie (A lecture delivered before the District Council for Edinburgh, Scotland, of the National Registration of Plumbers. The need of enlightenment in the proper use of gas. Points where gas fitters could educate their clients. 5,000 w.) Am Gas Lgt Jour—Feb. 8, 1897. No. 10,921. 15 cts.

GILLENDER Building, New York City. Plumbing in the (The peculiarity of dimensions led to unusual features in the disposition of the plumbing, which are herein described. 1,400 w.) Eng Rec—Jan. 16, 1897. No. 10,497. 15 cts.

HIGH-CLASS Plumbing, An Example of (Plans with description of plumbing in the Biltmore and the Blenheim apartment-houses, New York, with specifications. 2,800 w.) Met Work—Jan. 23, 1897. No. 10,570. 15 cts.

MISTAKES in Plumbing Practice, Some Common. W. F. Taaffe (A list of errors which plumbers are liable to fall into and that it would be well to avoid. 1,600 w.) San Plumb—Jan. 15, 1897. No. 10,479. 15 cts.

PIPES and Piping: Patterns, Materials and Methods Best Suited for Plant and Line Construction and Maintenance. C. P. Russell (Suggestions of importance in the distributing department of gas plants, relating to the selection of proper piping, materials, &c. 3,400 w.) Am Gas Lgt Jour—Feb. 1, 1897. Serial, 1st part. No. 10,703. 15 cts.

PUSHING the Plumbing Business. C. Gill (The Ironmonger's second prize essay. Suggestions as to attractive display of plumbing appliances, obtaining favor of architects, real estate agents, &c. 1,500 w.) Dom Engng—Jan., 1897. No. 10,744. 30 cts.

REGULATIONS, New Haven Plumbing (A copy of the regulations which recently went into effect. 2,800 w.) Met Work—Jan. 23, 1897. No. 10,571. 15 cts.

MISCELLANY.

ADVANCEMENT of Architecture, with Some Remarks on the Study of Gothic. George Aitchison (First lecture to the Royal Academy students. Interesting study of the subject. 4,800 w.) Brit Arch—Jan. 29, 1897. No. 10,951. 30 cts.

ATHENS, Classic Architecture in. Fred J. Orr (Describes and illustrates types of architecture in an old city in Georgia. 1,800 w.) So Arch—Jan., 1897. No. 10,347. 30 cts.

BLOCKS, Ornamented Building. E. G. Durant (Describes the making of these blocks, and tells how they came to be introduced. 1,100 w.) Brick—Jan., 1897. No. 10,346. 15 cts.

BRICK Making in Australia. Frank W. N. King (Illustrated account of this industry, giving information of quality, wages, &c. 1,500 w.) Brick—Jan., 1897. No. 10,344. 15 cts.

BRICKWORK Tests (Report on the second series of experiments, by William C. Street and Max Clarke, with appendices by Prof. Unwin. Ill. 7,000 w.) Jour Roy Inst of Brit Arch'ts—Dec. 17, 1896. No. 10,515. 75 cts.

BRICKWORK Tests (Discussion of the report of the second series of experiments. 7,500 w.) Jour Roy Inst of Brit Arch'ts—Dec. 31, 1896. No. 10,674. 30 cts.

CLAYS, Mixing, Preparing and Burning (Information intended as aid for men of limited experience. 3,000 w.) Brick—Jan., 1897. No. 10,345. 15 cts.

DAMME, a City of the Netherlands. J. Tavenor Perry, in the Journal of the R. I. B. A. (Illustrated description of interesting architecture in a town founded in 1178. 1,500 w.) Arch and Build—Jan. 9, 1897. No. 10,333. 15 cts.

DECORATION, Modern. Jean Schpofer (Comments on the lack of progress in the nineteenth century in the art of ornamentation. Criticises the decoration of modern apartments and notes some efforts to give decoration a new direction. Ill. 3,500 w.) Arch Rec—Jan.-March, 1897. No. 10,629. 30 cts.

ELECTRIC LIGHTING, Architects and (An attempt to indicate some ways by which good electrical work may, by the help of the architect, be made obligatory and at the same time cheaper. 2,800 w.) Arch, Lond—Jan. 1, 1897. No. 10,385. 30 cts.

ENGLISH Architecture of 1896, The. Mr. Statham (Extract from article in "The Year's Art." Review of work completed and proposed and matters of interest relating to architecture. 1,600 w.) Brit Arch—Jan. 15, 1897. No. 10,610. 30 cts.

EXHIBITIONS, German Achievements in. L. von Krockow (The achievements of German architects in the fairs in Berlin and Dresden. 2,000 w.) Am Arch—Jan. 30, 1897. No. 10,701. 15 cts.

HANOVER Chapel. Paul Waterhouse (A tribute of appreciation of the qualities of a recently demolished building in Regent street, London, and of the architect. 1,800 w.) Jour Roy Inst of Brit Arch—Dec. 31, 1896. No. 10,672. 30 cts.

HARDENBERGH, Henry Janeway, The Works of. Montgomery Schuyler (Biographical sketch with illustrated description of the best work of this noted architect. 9,300 w.) Arch Rec—Jan.-March, 1897. No. 10,633. 30 cts.

INTERLACED Ornament, Celtic (Illustrated description of the beautiful designs used in stone, metal work, and illuminated manuscripts of ancient Irish art, with account of their origin. 1,500 w.) Arch, Lond—Jan. 1, 1897. No. 10,383. 30 cts.

PETERBOROUGH Cathedral: Actual State of the Front (Editorial condemnation of the method of restoration advocated by the Soc of Antiquaries. 3,500 w.) Builder—Jan. 23, 1897. No. 10,854. 30 cts.

PLASTERWORK, Decorative. E. Prioleau Warren (Read before the London Archts. Assn. suggestions as to the treatment of plaster work, its uses and abuses. 7,800 w.) Builder—Jan. 23, 1897. No. 10,855. 30 cts.

REFRIGERATION. Alfred Siebert (As applied to dwellings, hotels, hospitals, business houses and public institutions. 3,000 w.) Jour Assn of Engng Socs—Dec., 1896. No. 10,637. 30 cts.

SICILY, the Garden of the Mediterranean. Albert M. Whitman (An interesting article written in popular style, giving the history, description of the beautiful architecture and much information of this lovely island. Ill. 5,500 w.) Arch Rec—Jan.-March, 1897. No. 10,631. 30 cts.

STACKS, A Story of. See same title under Mechanical Engineering, Boilers, Furnaces and Firing.

STUDY of Architecture, The Proper George Aitchison (Address delivered to the students of the R. I. B. A. Presents the importance of diligence, and reviews the things of greatest importance to the success of architects. 3,200 w.) Brit Arch—Jan. 22, 1897. No. 10,853. 30 cts.

TALL BUILDINGS and the Speed of Elevators. George Hill (Letter to the editor placing the economical limit of height at sixteen stories, and giving suggestions for safety from fire and wind pressure. 900 w.) Eng Rec—Feb. 6, 1897. No. 10,923. 15 cts.

THOROUGHFARES, Characteristics of Some Great London (A series of articles enlarging upon the aspects of some of the London roads and streets, and calling attention to beauties and points of interest, with discussion of proposed changes. 2,000 w. Arch, Lond—Jan. 1, 1897. No. 10,382. 30 cts.

TWOMBLEY Estate, The (Some architectural, engineering and structural features of the improvement, arrangement and equipment of a park and model farm and buildings. Ill. 1,500 w.) Eng Rec—Feb. 6, 1897. No. 10,925. 15 cts.

VILLAS of Rome, The. Marcus T. Reynolds (Illustrated description of these beautiful buildings, with a study of the social causes that led to the erection of this type of dwelling. 9,500 w.) Arch Rec—Jan.-March. 1897. No. 10,630. 30 cts.

CIVIL ENGINEERING.

BRIDGES.

BRICKWORK and Masonry. (Editorial comment called forth by the extensive series of tests on the strength of brick piers being made under the direction of the Inst of British Archts. 1,600 w.) Engng—Jan. 1, 1897. No. 10,402. 30 cts.

BRIDGE from Fort Washington to Kingsbridge, New York City, A Proposed. (Brief illustrated description of design by W. B. Parsons. 400 w.) Eng News—Feb. 4, 1897. No. 10,901. 15 cts.

BRIDGE Transportation System Between New York and Brooklyn, The. (Full illustrated description, including engineering features, conditions of traffic, operation of cable railway, adoption of electricity, terminal facilities, and financial results. 4,700 w.) St Ry Jour—Feb., 1897. No. 10,728. 45 cts.

CORNER-STONE of a Structure. Origin

of Ceremonies Connected with the Laying of the. (From Le Genie Civil. Investigation of such observances, especially in the laying of the corner-stone of bridges. 1,100 w.) Eng News—Jan. 21, 1897. No. 10,555. 15 cts.

REPACKING a Main Truss Chord Pin. E. F. Terry (Letter giving illustrated description of method of changing bars in the bottom chord of a bridge. 600 w). Eng Rec—Jan. 30, 1897. No. 10,679. 15 cts.

ROCK ISLAND Bridge, The New United States. (Part first gives history and description, general data, requirements, manufacture and erection. Ill. 3,000 w.) Eng Rec—Jan 30, 1897. Serial. 1st part. No. 10,678. 15 cts.

STRESSES in Bridge Members, Maximum. L. N. Hoskins (Considers in as general a manner as possible the problem of determining what position of a given series of moving loads will produce the greatest stress in any member of a bridge truss. Mathematical discussion. 4,700 w). Trans of Wis Acad. Vol. X. No. 10,423. 45 cts.

CANALS, RIVERS AND HARBORS.

DANUBE-ELBE CANAL. The Danube-Moldan-Elbe Canal (Der Donau-Moldau-Elbe-Canal.) (An official account of the plans for the canal communication between Vienna and the North Sea. 15,000 w. and 3 plates of map and profiles.) Oesterr Monatsschr f d Oeffent Baudienst—Jan., 1897. No. 10,776. 30 cts.

DANUBE, Regulation of. Report of the Commission for the Regulation of the Danube at Vienna (Bericht der Donau-Regulierungs-Commission in Wien.) (The official report of the commission for the work done in 1895. 7,500 w.) Oesterr. Monatschrift f d Oeffent Baudienst—Jan., 1897. No. 10,775. 30 cts.

DEBRIS, Responsibility for. (Data aiming to prove that hydraulic mining was not the chief cause of the evils complained of, but that the Sacramento River has been raising its channel and increasing the swamps for centuries. 1,100 w.) Min & Sci Pr—Jan. 9, 1897. No. 10,425. 15 cts.

DRAINAGE Canal, The Chicago (This series of articles proposes to consider the immediate purpose of this great work, and to describe the manner in which the canal has been constructed. 3,400 w.) Engng—Jan. 1, 1897. Serial. 1st part. No. 10,398. 30 cts.

GALVESTON Harbor Works, The. W. J. Sherman (Illustrated historical account of the work of harbor improvement at this point. 3,000 w.) Jour Assn of Engng Socs—Dec., 1896. No. 10,639. 30 cts.

GREAT LAKES to the Sea, Joining the (Conclusions of the commission appointed by Pres. Cleveland to consider this matter. They think the plan feasible and make suggestions as to route. 1,000 w.) Bradstreet's—Jan. 23, 1897. No. 10,561. 15 cts.

INLAND NAVIGATION. The Waterways of France compared with those of Germany (Die Wasserstrassen Frankreichs, verglichen mit jenen Deutschlands.) (A comparison of the extent, carrying capacity and efficiency of the internal waterways of the two countries. 1,500 w.) Zeitschr d Oesterr Ing u Arch Vereines—Jan. 15, 1897. No. 10,756. 15 cts.

HARBORS and Waterways (Editorial review of changes and improvements during the past year. 2,000 w.) Eng, Lond—Jan. 1, 1897. No. 10,408. 30 cts.

LAKES to the Ocean, From the (Editorial on the report of the United States Deep Waterways Commission. 1,400 w.) RR Gaz—Feb. 5, 1897. No. 10,907. 15 cts.

NICARAGUA Canal Again, The (Editorial criticism of the attitude of the officers of the company, with statement of the situation. 900 w.) RR Gaz—Jan.fl 29, 1897. No. 10,684 15 cts.

NICARAGUA Canal, The (Editorial summing up briefly the situation. 1,500 w.) RR Gaz—Jan. 22, 1897. No. 10,567. 15 cts.

PANAMA Canal, The New (Showing the project as provisionally adopted. Profile is given. 1,800 w.) RR Gaz—Jan. 15, 1897. No. 10,458. 15 cts.

ROCK DREDGING on the Rhine (Brief illustrated description of an important work in progress in the bed of the Rhine, with methods employed and appliances used. 2,000 w.) Eng., Lond—Jan. 8, 1897. No. 10,510. 30 cts.

TOOLS Used in Construction of the New U. S. Lock at Sault Ste. Marie, Special (Illustrated description of devices easily made which served their purpose admirably. 900 w.) Eng News—Jan. 14, 1897. No. 10,449. 15 cts.

IRRIGATION.

HYDROGRAPHIC SURVEYS in Montana. A. M. Ryan (A review of the work done and the methods employed in the measurement of the flow of rivers and streams in Montana. 2,200 w.) Sch of Mines Quar—Nov., 1896. No. 10,936. 45 cts.

NAVAHO Reservation, Recent Irrigation Work on—Cosmos Mindeleff. (A brief illustrated account of the work to benefit the reservation, but largely devoted to description of the tribe inhabiting the region. 2,000 w.) Sci Am—Jan. 23, 1897. No 10,534. 15 cts.

WASHINGTON, Irrigation in Yakima County—A. B. Wyckoff. (An illustrated description endeavoring to show the results of irrigation. 1,500 w.) Sci Am Sup—Jan. 16, 1897. No. 10,438. 15 cts.

MISCELLANY.

BRICKWORK, Tests. See same title under Architecture, Miscellany.

CEMENT, Revision of the Method of Making Tests of (Report of the Board of Directors of the American Soc. of Civ. Engs., in the matter of the proposed appointment of a special committee to report on the proper manipulation of tests of cement. 800 w.) Eng. Rec.—Jan. 23, 1897. No. 10,596. 15 cts.

CIVIL ENGINEERING. (Review of the year in the various branches of civil engineering, with comment on the changed conditions. 3,300 w.) Eng Lond—Jan 1, 1897. No. 10,406. 30 cts.

CONCRETE, Wall on Clinton Ave., Brooklyn, The (Illustrated description of a public improvement by which waste lands along a branch of the East River will be converted into a public marketplace, with buildings, piers and a basin and channel. 2,800 w.) Eng Rec—Jan 9, 1897. No. 10,334. 15 cts.

EXTENSION, of Amsterdam Avenue, New York, North from Fort George, Proposed (Illustrated description of a proposed extension by means of a steel viaduct and arches, which will greatly enhance the driving facilities of the northern part of Manhattan Island. 900 w.) Sci Am Sup—Feb. 6, 1897. No. 10,882. 15 cts.

JAPAN, Civil Engineering Prospects in (Notes of a few of the engineering projects which are being proposed as means for hastening the industrial and commercial development. 1,700 w.) Engng—Jan. 29, 1897. No. 10,945. 30 cts.

LIME, Hydraulic Cement, Mortar and Concrete. Clifford Richardson (This first part deals only with lime in its various forms. 1,800 w.) Br Build—Jan, 1897. Serial. 1st part. No. 10,658. 50 cts.

MONIER ARCH, The Theory of the Cement-Iron Construction—(Zur Theorie der Cement-Eisenconstruction—Monier Constructionen (A review of some previous articles, criticising the methods of computation used. By Prof. Josef Anton Spitzer. 2,500 w.) Zeitschr d Oesterr Ing u Arch Vereines—Jan. 8, 1897. No. 10,753. 15 cts.

SPEEDWAY, New York City, The Harlem River (Illustrated description, with editorial comment. 3,000 w.) Sci Am—Feb. 6, 1897. Serial. 1st part. No. 10,880. 15 cts.

TRANSVERSE Sections, The Resistance Areas of—A. E. Sharp. (Read before the Northeast Coast Inst of Engs. An explanation of the first principles of questions relating to beams and girders. 2,000 w.) Ind & Ir—Jan. 22, 1897. No. 10,721. 30 cts.

TUNNEL, Under the Spree, near Treptow, The (From Illustrirte Zeitung. Illustrated description of a tunnel undertaken to test the adaptability of the ground under Berlin for the construction of an underground railway. It is to form part of a future street railway from Treptow to the Silesian station. 900 w.) Sci Am Sup—Jan. 23, 1897. No. 10,543. 15 cts.

TOPOGRAPHICAL, Surveys, Their Methods and Value. J. L. Van Ornum (A lecture before the students of the College of Mechanics and Engineering, University of Wisconsin. Presents the value and utility of the topographical survey, with methods and variations in cost, scale and character of the work. Also notes showing how large a territory has been covered. 10,700 w.) Bul of Univ of Wis—Vol. 1, No. 10. No. 10,933. 35 cts.

VIADUCT at Sydney, N. S. W., Proposed Subaqueous (Illustrated description of a proposed plan to build a viaduct on top of the silt-bed, supported by piers carried down to the rock. 1,500 w.) Eng News—Jan. 21, 1897. No. 10,557. 15 cts.

WIND PRESSURES in the St. Louis Tornado. Julius Baier (The paper is presented with the object of placing on record some definite estimates made by the author, of the force exerted by the wind on several structures of known stability that failed under its action, and some further characteristic examples of destruction that will be indicative of this force. Ill. 21,500 w.) Pro Am Soc of Civ Engs—Jan., 1897. No. 10,737. 50 cts.

ECONOMICS AND INDUSTRY.

COMMERCE AND TRADE.

BALTIC Ports, Trade with the (Discusses the possibilities of commerce in northern Europe. 1,600 w.) Tradesman—Feb. 1, 1897. No. 10,726. 15 cts.

COMMERCIAL Geography of Europe, The—Cyrus C. Adams (Calls the attention to the importance of geography as a basis of commerce. American merchants should know regions and their resources, people and their peculiar ways and tastes, &c. 2,800 w.) Chau—Feb., 1897. No. 10,668. 30 cts.

COMPETITION, Foreign—Joseph Nasmith (Abstract of an inaugural address before the Manchester Assn of Eng. Considers the three most important factors that affect the problem to be, 1st, the economic effect of approved appliances; 2d, the adoption of the best commercial methods; 3d, the fullest development of the skill of all those engaged in an industry, and especially of the leaders. 3,500 w.) Col Guard—Jan. 15, 1897. No. 10,585. 30 cts.

COMPETITION, German Trade (Edi-

torial review of this subject and its effects, and the various causes that have led to the rapid growth of manufacturing industries in Germany. 3,500 w.) Engng —Jan. 29, 1897. No. 10,944. 30 cts.

EXPORT Trade, Pushing Our (Explains briefly the aims and purposes of the work of the Commercial Museums. 1,000 w.) Bradstreet's—Jan. 30, 1897. No. 10,675. 15 cts.

FAILURES, Records of (A statistical balance sheet, classified according to explained methods, and giving valuable information of credit ratings for the past six years. 9,000 w.) Bradstreet's—Jan. 23, 1897. No. 10,611. 15 cts.

IMPORT Duties in Foreign Countries on Dynomo-Electric Machinery and Electric Lamps (Statement of duties in the principal European countries and India, recently prepared by the English Board of Trade. 900 w.) Bd of Tr Jour—Jan., 1897. No. 10,692. 30 cts.

INDUSTRIES, The Future of American, —A. E. Outerbridge, Jr. (Address to students in economics and sociology in the Wharton School of Finance, University of Penna. An attempt to cast the horoscope of manufacturing industries in America for the opening of the new century. Growing expansion of commerce and manufactures and an era of industrial prosperity predicted. 3,500 w.) Jour Fr Inst—Feb., 1897. No. 10,918. 45 cts.

INTERCHANGE of Things Between Man and Man and Community, The Mechanism of (Syllabus of a lecture by Mr. Norman, given upon invitation of the Marylebone Teachers' Assn. The object was to demonstrate the progress secured by the use of one intermediary, entailing price and a rate of currency exchange, compared with exchange by direct barter. 1,000 w.) Bankers' Mag, Lond—Jan., 1897. No. 10,354. 30 cts.

JAPAN, The Commercial Expansion of. H. Tennant (A review of the remarkable progress of this country in recent years, calling attention to the advancement in commerce and manufactures and their effect on other countries, with discussion of the future probabilities. 4,000 w.) Contemporary Rev—Jan., 1897. No. 10,426. 45 cts.

PIG IRON, Southern (Extract from the London Iron and Steel Trades Journal, with letters from James Bowron, of the Tenn Coal & Iron Co. Remarkable growth of the foreign demand for it; countries to which it is exported; outlook for a continuation of the movement. 2,400 w.) Bradstreet's—Feb. 6, 1897. No. 10,928. 15 cts.

TARIFF Changes and Customs Regulations (Russia, Netherlands, Guiana, Belgium, Germany, France, Portugal, Southeast Africa, Spain, Cuba, Switzerland, Austria, Hungary, Turkey, United States, Mexico, Gautemala, Nicaragua, Costa Rica, Peru, Japan, British India, Natal and Leeward Islands. 11,000 w.) Bd of Tr Jour—Jan., 1897. No. 10.693 30 cts.

TARIFF, Revision of the (Letter to Hon. Nelson Dingley, Jr., Chairman of the Committee on Ways and Means, from the American Iron and Steel Assn, setting forth the views of the society on the question of a revision of the tariff. Gives a summary of the country's tariff history and considers changes believed to be required. 7,000 w.) Bul of Am Ir & St Assn—Feb. 1, 1897. No. 10,700. 15 cts.

CURRENCY AND FINANCE.

CURRENCY, The New Epoch and the—George S. Morison (Ascribes all the great advances of the nineteenth century to the capacity to manufacture power, and traces the effects. Traces the changes in business and shows the effect upon the currency. 4,700 w.) N Am Rev—Feb., 1897. No. 10,688. 45 cts.

GUINEA, The—(History of the coin with an estimate of its place and function in British monetary matters. 3,500 w.) Banker's Mag, Lond—Jan., 1897. No. 10,353. 30 cts.

MONETARY System, The Cure for a Vicious—W. A. Peffer (The steps that should be taken towards reforming the currency and placing the finances upon a stable basis. 4,500 w.) Forum—Feb. 1897. No. 10,691. 30 cts.

MONEY and Investments. (Discusses the uncertainty of present conditions. 5,000 w.) Contemporary Rev—Jan., 1897. No. 10,427. 45 cts.

REFORM, Imperative, Financial and Currency—Charles N. Fowler, (Discusses the cause of trouble over the money question, and states that an unequivocal position with regard to the standard of value, the adoption of a well-developed system of credit currency, and the adjustment of revenues to meet the expenses of the Government, are essential to prosperity. 3,500 w.) Forum—Feb., 1897. No. 10,690. 30 cts.

GOVERNMENTAL CONTROL.

CRISES, The Relation of Economic—to Erroneous and Defective Legislation, with Special Reference to Banking Legislation. Edw. D. Jones (Deals with legislation from an historic point of view. A study of the theory of crises and their development, specially presenting the privileges of the bank of England and the Peel Bank act of 1844. 12,000 w.) Trans Wis Acad, Vol X—No. 10,424. 45 cts.

OWNERSHIP, Report of a Special Committee of the Northwestern Electrical Association on Municipal and Opposition

(Really two reports, one submitted by H. L. Doherty, the other by E. Coleman. Abstracts. The reports give no new information. 2,200 w.) Elec—Jan. 27, 1897. No. 10,642. 15 cts.

SUBWAYS, Municipal ownership of—See same title under Electrical Engineering, Miscellany.

TOLLS, Emancipation of the Monongahela from—Graphical Determination of Value of Franchises. Lewis M. Haupt (The importance of the improvement on the Monongahela, with method of determining value and the benefit of removing tolls. 1,700 w.) R R Gaz—Feb. 5, 1897. No. 10,904. 15 cts.

LABOR.

ARBITRATION in the Boot and Shoe Industry, Conciliation and. T. A. Carroll (Review of methods adopted and a study of results, obstacles, &c., with comparison of different plans. 17,300 w.) Bul of Dept of Labor—Jan., 1897. No. 10,468. 45 cts.

CONVICT Labor Problem, The. (Explains position taken in former article and further discusses the question. 1,800 w.) Gunton's Mag—Feb., 1897. No. 10,885. 30 cts.

LAND TAXATION and Labor Laws in New Zealand (Details of each different system under which land may be obtained in this colony; also reasons why the writer cannot encourage immigration from the United States, with discussion of labor conditions. 40,000 w.) Cons Repts—Jan., 1897. No. 10,488. 45 cts.

MR. CARNEGIE'S Johnstown Address (An extract giving the speaker's opinion of the cause of business depression and the relation of capital and labor. 1,800 w.) Ir Tr Rev—Jan. 28, 1897. No. 10,695. 15 cts.

PIECE WORK vs. Day's Work. See same title under Mechanical Engineering, Shop and Foundry.

PROFITS, Labor's Share of (Editorial showing that the benefit to the working classes from increased share of profits is not due to what the trade union advocates have done, but has followed upon events which were prompted by capital. The benefits arising from the Limited Liability Act are discussed. 1,800 w.) Engng—Jan. 15, 1897. No. 10,582. 30 cts.

MISCELLANY.

ARBITRATION Treaty, Anglo-American (Full text of the treaty as signed by the representatives of the two governments. 2,000 w.) Gunton's Mag—Feb., 1897. No. 10,886. 30 cts.

BETTERMENT, A Century of Social. John Bach McMaster (Reviews the great progress in methods of business, appliances which promote health, wages, comforts for all classes, advancement of science, material comfort and spirit of broad humanity. 4,500 w.) Atlantic M—Jan., 1897. No. 10,574. 35 cts.

ECONOMICS, Practical versus Metaphysical (Refers to the tendency to study economics from hypothetical rather than actual phenomena, and pronounces the doctrine of marginal utility to be unclear and unpractical. 4,000 w.) Gunton's Mag—Feb., 1897. No. 10,883. 30 cts.

FACTS versus Economic Theories. Hartley Withers (An extended criticism of the so-called science of economics, asserting that its study is an intellectual exercise, interesting but practically useless, and that if it is ever to be a science in the true sense, economists must study the phenomena of business much more closely. 4,000 w.) Bankers' Mag, Lond—Jan., 1897. No. 10,352. 30 cts.

GOLDSMITH'S, Trade and Its Relation to Wealth, The—Paul Gaultier (Brief historical review of the working of the precious metals and their effect upon the world. 2,700 w.) Chau—Feb., 1897. No. 10,669. 30 cts.

INVENTIONS. The Right of Employers to the Inventions of Employees (Das Recht des Dienstherrn an Erfindungen von Angestellten. An examination of this important subject, with recommendations in connection with German patent law. 2,500 w.) Glaser's Annalen—Jan. 15, 1897. No. 10,785. 15 cts.

LIVING, American Standard of (The variations in wages in different countries said to be due to the standard of living. Comparison with other countries is made, and the life of the workingman is shown to be broader in America than in Europe. 2,500 w.) Gunton's Mag—Feb., 1897. No. 10,884. 30 cts.

RUBBER Cultivation, the Outlook for—Gustav Mann (An interesting article in which the writer gives his opinion that all rubber plants had better be grown in the countries in which they are indigenous. This paper is followed by several short articles on related subjects. 1,500 w.) Ind Rub Wld—Feb. 10, 1897. No. 10,965. 45 cts.

STATISTICS (Editorial review of the blue-book of the Board of Trade; the forty-third issue of the Statistical Abstract for the U. K. in each of the last fifteen years. A study of the report shows fair indications of advancing prosperity. 4,000 w.) Engng—Jan., 1897. No. 10,401. 30 cts.

TECHNICAL Education in Germany, The Recent Progress of (Abstract of a report on the recent progress, dated Dec., 1896, and issued as a blue book. 1,800 w.) Col Guard—Jan. 22, 1897. No. 10,714. 30 cts.

ELECTRICAL ENGINEERING.

ELECTRO CHEMISTRY AND METALLURGY.

CHEMISTRY (Editorial review of the past year, containing report of progress in electro-chemistry and metallurgy. 2,500 w.) Eng, Lond—Jan. 1, 1897. No. 10,412. 30 cts.

CRUCIBLE Fusions, The Use of Electricity for—F. H. Leeds (Shows that wherever there is water-power available it is considerably cheaper to conduct crucible fusions by means of electricity than by direct coal firing; and that possibly in the future it may also be found advantageous to employ coal for the preparation of electricity, rather than to fire a crucible furnace with it direct. 2,400 w.) Elect'n—Jan. 22, 1897. No. 10,852. 30 cts.

CARBORUNDUM at Niagara Falls, The Manufacture and Development of. Francis A. Fitzgerald (Traces the manufacture of carborundum from the preparation of the crude material for the mixture to the production of grains and powders in a commercial form and considers its properties and uses. Ill. 5,500 w.) Jour Fr Inst—Feb., 1897. No. 10,916. 45 cts.

ELECTROLYSIS, New Carbon Terminals for (Neue Kohlen für Elektrolyse) (Lessing's new fused carbon sheets are for use in commercial electrolysis, and are claimed to be unaffected chemically or mechanically by the action of the bath. 1,000 w.) Elektrochemische Zeitschr—Jan., 1897. No. 10,793. 30 cts.

ELECTROLYSIS, The Separation of Metals by Means of Soluble Anodes (Trennung von Metallen mittelst löslicher Anoden) (A method of determining antimony quantitatively by electro deposition from solution upon a copper cylinder. 500 w.) Elektrochemische Zeitschr—Jan., 1897. No. 10,794. 30 cts.

FURNACE, Electric—for Distillation of Metals (Elektrischer Destillierofen) (A convenient laboratory furnace for distilling metals at very high temperatures. 800 w.) Elektrochemische Zeitschr—Jan., 1897. No. 10,795. 30 cts.

MECHANICAL Theory of Electricity and Chemical Action. Arthur Whitwell (The object is to develop the idea of molecular rotation and to suggest by its aid a mechanical picture of electrostatic, electromagnetic, magnetic and chemical phenomena. 1,600 w.) Elec Rev, Lond—Jan. 8, 1897. Serial, first part. No. 10,495. 30 cts.

REVIEW Electro-Chemistry in 1896 (Elektrochemie im Jahre 1896) (A general review of the progress of this branch of science for the past year, with numerous references to journals and patents. 7,500 w.) Elektrochemische Zeitschr—Jan., 1897. No. 10,796. 30 cts.

LIGHTING.

ARCHITECTS and Electric Lighting. See title Electric Lighting, under Architecture. Miscellany.

ARC Lighting, Fifteen Years' Progress in—Elihu Thomson (A review of the period which covers nearly all the commercial development of arc lighting on a large scale. 2,000 w). Elec Eng—Jan. 6, 1897. No. 10.315. 15 cts.

ARC Light, The Enclosed—L. B. Marks (Read before the Société Internationale des Electriciens, Paris, France. Points out the distinction between the ordinary arc and the enclosed arc; gives a sketch of the earlier history of the art of enclosing arc lighting, with details of the subject. 1,800 w). Elec Eng—Jan 27, 1897. Serial. 1st part. No. 10,650. 15 cts.

BIRKENHEAD Electricity Works. (Illustrated detailed description. 3,700 w.) Elec Eng, Lond—Jan. 15, 1897. No. 10,622. 30 cts.

BRITISH GUIANA, Electric Lighting in—Samuel Vyle (Brief account of the introduction. 1,500 w). Elect'n—Jan. 29, 1897. No. 10,950. 30 cts.

CENTRAL STATION Economics. Arthur V. Abbott and Franz J. Dommerque (A collection of information particularly relative to central station practice, arranged in form for ready reference, intended to embrace all information of value as relating to profitable design and operation of central stations. 41,500 w). Elec Engng—Feb., 1897. No. 10,738. 25 cts.

CENTRAL STATION Operation, Fifteen Years in. Samuel Insull (A history of development and growth. 2,200 w). Elec Eng—Jan. 6, 1897. No. 10,316. 15 cts.

DISTRIBUTION and Diffusion of Light. E. L. Elliott (Abstract of a paper read before the N. Y. Elec. Soc. The problems of distribution and diffusion are discussed and the effect of various globes. 2,800 w). Elec Wld—Jan. 23, 1897. No. 10,660. 15 cts.

GAS ENGINE, The Determination of the Cost of Electric Lighting by—J. L. Christy and S. A. Hasbrouck (Abstract of thesis submitted before the Stevens Inst. of Technology. Describes engine and gives tables of tests containing data taken at the engine; the averages for each test, and a table of comparison of costs at different loads. 1,000 w). Am Gas Lgt Jour —Jan. 25, 1897. No. 10,608. 15 cts.

INCANDESCENT Lamps. Franklin S. Terry (Abstract of paper read before the Northwestern Elec. Assn. Points of Practical interest to the central station. 2,500 w). Elec Eng—Jan. 27, 1897. No. 10,651. 15 cts.

INCANDESCENT Lamp, Past and Future, The (Review of the changes and their effect upon the industry at large. 1,100 w). Elec Eng—Jan. 6, 1897. No. 10,319. 15 cts.

ISLE OF MAN, Electricity in the. (Extract from report of the Town Clerk of Douglas, in which the cost of electric lighting is dealt with. 2,000 w). Gas Wld—Jan. 2, 1897. 30 cts.

ISOLATED Electrical Plant During the Last Fifteen Years, The Evolution of the —Charles Henry Davis (Treats of the isolated plant located in the building which it serves. Part first describes the generating plant. 700 w). Elec Eng—Jan. 6, 1897. Serial. 1st part. No. 10,314. 15 cts.

ISOLATED Plants. Cost of Electric Lighting from Public and Private Supply. F. J. Warden-Stevens (Curves, with explanation, showing cost of lighting from supply mains and from a private plant, given in order to show approximately when it is advisable to adopt a separate plant. 1,300 w). Elec Rev, Lond—Jan. 8, 1897. No. 10,496, 30 cts.

ISOLATED Plant. Electric Lighting at the New Waldorf Hotel, N. Y. (Brief description of what will be one of the most extensive plants of its kind in the country. 600 w.) Elec Rev—Jan. 13, 1897. No. 10,415. 15 cts.

LAUNCESTON, Tasmania, the Lighting of (Illustrated detailed description. 4,200 w.) Elec Rev, Lond—Jan. 1, 1897. No. 10,332. 30 cts.

MALTA Electricity Supply (Illustrated detailed description. 2,400 w). Elec Rev, Lond—Jan. 22, 1897. No. 10,858. 30 cts.

MANCHESTER Corporation Electric Works. C. H. Wordingham (Describes the five-wire method, the distributing network, insulating troughs, cables, feeders, generating plant, engines, boilers and extensions. 3,800 w). Prac Eng—Jan. 22, 1897. No. 10,859. 30 cts.

MUNICH, The Electric Plant of the City of (Die Städt ischen Elektricitätswerke Münchens. A very complete account of the steam and hydraulic power plant, electric generators, lighting and distribution, with numerous illustrations. 6,000 w). Elektrotechniscshe Zeitschr—Jan. 7, 1897. No. 10,797. 15 cts.

MUNICIPAL OWNERSHIP. See title Ownership, under Economics and Industry, Governmental Control.

STATIONS, Pioneer Electric Light (Brief historical sketch of the Kensington Court Station, with a résumé of improvements already added or in course of construction. 2,500 w.) Elec Eng, Lond—Jan. 1, 1897. No. 10,396. 30 cts.

STEAM ENGINEERING of To-Day and To-Morrow, The—R. H. Thurston (The article deals with the subject of the steam engine for electric lighting principally, reviews progress and describes the modern engine. 2,800 w). Elec Eng—Jan. 6, 1897. No. 10,317. 15 cts.

ST. HELENS, Electricity Works (Illustrated detailed description. 3,300 w.) Elec Eng, Lond—Jan 15, 1897. No. 10,623. 30 cts.

TRANSFORMERS, Protective Devices for—Herbert C Wirt (Read before the Northwestern Elec Assn. Calls attention to devices which have been designed to render the transformer absolutely safe. Also suggests precautionary measures. 1,800 w). Elec Rev—Jan. 27, 1897. Serial 1st part. No. 10,643. 15 cts.

WIRING, Free (Discussion from the private householder's point of view, and with relation to the effect on the supply, undertaking and the cost per unit. 1,800 w.) Elec, Lond—Jan 1, 1897. No. 10,490. 30 cts.

UNDERGROUND Lighting by Electricity, Notes on—John Daw (Read before the Inst of Min and Met. Brief description of a portable electric lamp. 1,400 w.) Min Jour—Jan 23, 1897. No. 10,716. 30 cts.

POWER.

ADVANCE in the Near Future, Lines of—H. H. E. (Discusses the possibilities for the useful application of the electric current, predicting that it will find its greatest activity in industrial establishments, 800w). Ir Tr Rev—Jan. 21, 1897. No. 10,621. 15 cts.

BROOKLYN BRIDGE, New Electric Power Plant, The (Illustrated detailed description, with a few statistics relating to the construction and operation of the bridge. 4,300 w.) Elec Wld. Jan. 23, 1897. No. 10,659. 15 cts.

CENTRAL Electric Station of the Davis Coal and Coke Co. Timothy W. Sprague. (Illustrated description of plant and its operation. 2,200 w.) Eng & Min Jour. Jan. 23, 1897. No. 10,560. 15 cts.

DISTRIBUTION of Power in Workshops, &c., The Local—Ernest Kilburn Scott. (Presents the advantages of electric transmission in factories and workshops. 2,500 w.) Elec Eng Lon—Jan. 1, 1897. Serial. 1st part. No. 10,395. 30 cts.

DYNAMO. Elementary Practical Electricity. F. L. Hutchinson. (Designed to explain in a simple manner the fundamental principles upon which dynamos and motors depend in their action. 1,500 w.) Ry Mas Mech—Jan., 1897. Serial, 1st part. No. 10,349. 15 cts.

ECONOMIES of Electrical Transmission of Power, The—Walter Dixon (Part first reviews the methods for distributing power in iron and steel works, and shows that the results can be immeasurably improved by the application of electricity. 2,200 w.) Ir & Coal Trds Rev—Jan. 22, 1897. Serial. 1st part. No. 10,720. 30 cts.

ELECTRIC, Central Stations versus Isolated Plants. R. S. Hale (Controverting analytically the claim of Max Osterberg, that the isolated plant will gradually displace the Central Station. 4,800 w.) Eng Mag—Feb., 1897. No. 10,299. 30 cts.

ELECTRICITY in the Government Printing Office. (Abstracts of reports of Chief Engineer George E. Ried and Chief Electrician W. H. Tapley, giving valuable details of the operation and economy of the plant. 4,000 w.) W Elec—Jan. 30, 1897. No. 10,702. 15 cts.

EQUALIZER, The (Explains the action of the Equalizer. 1,500 w). Am Elect'n—Jan., 1897. No. 10,546. 15 cts.

EQUIPMENT of Manufacturing Establishments with Electric Motors and Electric Power Distribution, The. Dugald C. Jackson. (Summary of views held in various great establishments where experience has been had, dealing especially with conditions existing in concerns owning and operating their own plant. Compares mechanical and electrical distribution. 7,400 w.) Jour of W Soc of Engs—Dec., 1896. No. 10,472. 45 cts.

EQUIPMENT of the Hotel Manhattan, The Electrical (Brief illustrated description of the complete electrical equipment which has been installed in this hotel. 2,500 w.) Elec Wld—Jan. 9, 1897. No. 10,441. 15 cts.

FARMS, Electricity on (Description of an electrical plant as introduced on a farm in Mecklenburg. Shows a difference in expenses of $285.60 in favor of the electric plant. 1,000 w.) Cons Repts—Jan., 1897. No. 10,578. 45 cts.

GENERATING Electricity, Motive Power for (Review of E. Tremlett Carter's "Treatise on the Theory of the Mechanical Equipment of Power Stations," quoting also from N. W. Perry's paper favoring the use of gas engines for generating electricity. 2,000 w). Jour of Gas Lgt—Jan. 5, 1897. No. 10,445. 30 cts.

GENERATOR, The design of 100 K. W. 500 Volt Power—H. J. Ryan and I. J. Macomber (The two general methods that may be used for designing a dynamo are stated, with outlines and explanatory notes for the design of direct current generators and motors. 5,500 w.) Sibley Jour of Engng—Jan., 1897. No. 10,635. 30 cts.

MINING PURPOSES, The Use of Electrical Power for (The series of articles proposes to consider the suitability of the system to general mining conditions in competition with other power systems and the circumstances under which it is in actual practice, and may be applied to coal-cutting, haulage, pumping, lighting and other purposes. 2,200 w.) Ir & Coal Trds Rev—Jan. 15, 1897. Serial. 1st part. No. 10,595. 30 cts.

NIAGARA, The Acccomplished Utilization of—W. B. Rankine (Data as to the result of the enterprise, with a list of contracts for power to Nov., 1896. 600 w.) Elec Eng—Jan. 6, 1897. No. 10,321. 15 cts.

NIAGARA Power Celebration, The Buffalo (Account of the banquet given Jan. 12, 1897, in celebration of the successful power transmission. 5,600 w.) Elec Eng—Jan. 20, 1897. No. 10,525. 15 cts.

PAPER MILLS. The Electric Transmission of Power in the Paper Mill at Biberist (Die Elekhrische Kraftübertagung der Papier-fabrik Biberist). This is one of the longest in Europe, 365 H. P. being transmitted nearly 18 miles. 4,000 w.) Elektrotech Rundschau—Jan. 15, 1897. No. 10,788. 15 cts.

PATERSON, N. J., New Station of the Edison Electric Illuminating Company of (The company furnishes not only arc and incandescent light and miscellaneous power, but also the current for operating the electric railroad. Illustrated description. 1,800 w.) Power—Feb., 1897. No. 10,872. 15 cts.

PROGRESS in the Adaptation of Electricity. M. J. H. (A review of recent progress due to the development of the transmission of power over long distances, especially in mining work. 2,000 w.) Ir Tr Rev—Jan. 21, 1897. No. 10,620. 15 cts.

SHUNT MOTOR, Practical Method of Differential Compounding a—for Constant Speed at All Loads. Reese Hutchison (A practical and reliable way is described. 600 w.) Am Electn—Jan., 1897. No. 10,545. 15 cts.

SPEED and Efficiency of a Dynamo, Note on the Relation Between the—Arnold G. Hansard (A graphic solution of this problem, giving the rather unexpected result that the speed which gives the highest efficiency is that which makes the eddy-current losses equal to the C2R losses. 700 w.) Elect'n—Jan. 22, 1897. No. 10,851. 30 cts.

STORAGE BATTERY to Electric Traction, The Application of the—Charles Hewitt (Deals with the application of the battery on the car or locomotive, to long lines, and in the power-house itself, giving two applications in the writer's personal experience. The writer thinks

there is a wide and growing field in the application to long lines and in the power-station, but not to moving vehicles. Ill. 6,500 w.) Pro Engs Club of Phila—Jan., 1897. No. 10,967. 45 cts.

THREE-WIRE Distribution, New Dynamo for—M. Aliamet (From L'Elestricien. Illustrated description of arrangements for enabling the two sides of the three-wire system to be fed by means of a single dynamo, and the solution of the problem by M. Müller. 900 w.) Elec Rev Lond—Jan. 22, 1897. No. 10,857. 30 cts.

TRANSFORMERS, Improvements in Continuous Current (Calls attention to modifications of the original scheme by which the generating plant has been simplified and low-pressure distribution arranged on a three-wire system. The full load efficiency has been increased more than 5 per cent. in less than two years. Ill. 1,000 w.) Electn—Jan. 8, 1897. No. 10,512. 30 cts.

TRANSMISSION, Long Distance—Charles P. Steinmetz (Reviews the progress of transmission for lighting, mechanical power and electric railroading. 1,600 w.) Elec Eng—Jan. 6, 1897. No. 10,320. 15 cts.

TRANSMISSION, Recent Advances in Power—John McGhie (Showing the important place now occupied by electric power. 900 w.) Elec Eng—Jan. 13, 1897. No. 10,432. 15 cts.

WATER WHEELS, The Efficiency of. F. M. F. Cazin (Letter to the editor criticizing statements made in an article by Wm. Blaue, published Sept. 12, 1896. Also showing the importance to the electrician of water-wheel efficiency. 1,300 w.) Elec Wld—Jan. 9, 1897. No. 10443. 15 cts.

WORKS Operated by Electricity, Nut and Bolt. (Describes and illustrates the factory of Messrs. Plumb, Benedict & Bernard at North Tonawanda, N. Y., which is to be operated by power from Niagara. 900 w.) RR Gaz—Jan. 29, 1897. No. 10683. 15 cts.

WORM-GEARING, Electrical Tests of the Efficiency of. (Diagrams showing results of actual tests upon the double-worm elevator of the Sprague Electric Elevator Co. 1,800 w.) Am Mach—Jan. 21, 1897. No. 10550. 15 cts.

TELEGRAPHY AND TELEPHONY.

BELL TELEPHONE Exchange at Larchmont, New Southern (Illustrated description. 500 w.) Elec Eng—Jan. 13, 1897. No. 10,434. 15 cts.

BERLINER Patent Situation, The (Gives the more important portions of the Patent Office records which bear directly upon the invention of the microphone. 4,700 w.) Elec Wld—Jan. 30, 1897. No. 10,862. 15 cts.

DUPLEX, The Müller-Wilke Telegraph-Telephone (Müller-Wilke's Telegraphen-Fernsprecher. A system of simultaneous telegraphing and telephoning over a single wire, especially adapted for railway service. 2,500 w.) Deutsche Zeitschr. f. Elektrotech—Jan. 15, 1897. No. 10,792. 15 cts.

INTERNATIONAL Telegraphs (Particulars from official and other sources relating to the International Bureau of the Telegraphic Administrations. 3,000 w.) Elect'n—Jan. 15, 1897. No. 10,604. 30 cts.

KITES, The Use of a Mid-Air Telephone Wire with—Wm. A. Eddy (An illustrated account of a successful experiment. 1,200 w.) Elec Eng—Jan. 6, 1897. No. 10,324. 15 cts.

PARTY LINE Telephone Systems, Recent Improvements in (Description of a system brought out by the American Telephone and Telegraph Co. Illustration of instrument. 1,000 w.) Elec Eng—Jan. 27, 1897. No. 10,649. 15 cts.

RICHMOND Telephone System, The (Illustrated description. 2,300 w.) Elec Wld—Jan. 16, 1897. No. 10,520. 15 cts.

SUBMARINE Cablegraphy, Fifteen Years' Advance in—George G. Ward (Review of improvements and advances as observed in the North Atlantic. The points noted are the increase in facilities, rapidity, legibility, accuracy and cheapness of service. 1,300 w.) Elec Eng—Jan. 6, 1897. No. 10,323. 15 cts.

SUBMARINE Cables, Localizing Earth Faults in—by Tests from One End Only. J. Rymer (Explains a test, capable of great accuracy, where results from one end only have to be relied upon to determine the position of a partial earth or broken conductor. 3,000 w.) Elec Rev Lond—Jan. 1, 1897. No. 10,391. 30 cts.

SUBMARINE Telegraphy (Presidential address of Sir Henry Mance to the Inst. of Elec. Engs., with biographical sketch of the speaker. Many interesting points connected with this work are brought out, with notes from personal experience. 7,500 w.) Elect'n—Jan. 15, 1897. Serial, first part. No. 10,605. 30 cts.

TELEGRAPHY, Fifteen Years of—William Maver, Jr. (A review of changes some of them very important, and of improvements in submarine telegraphy, of the increase of mileage and other interesting points. 3,000 w.) Elec Eng—Jan. 6, 1897. No. 10,322. 15 cts.

TELEPHONY, Dr. V. Wietlisbach (A republished revised edition of the first 110 pages of this work which the writer is contributing to Electrical Engineering. It is said to be the most thorough and complete work on telephony ever written. 3,000 w.) Elec Eng—Jan., 1897. No. 10,355. 25 cts.

MISCELLANY.

ALTERNATING Currents, Conductor Resistance Met by. Dugald C. Jack-

son (A consideration of "skin-effect" and its importance, with the development of formulae. 1,200 w.) Elec Wld—Jan. 16, 1897. No. 10,521. 15 cts.

ALTERNATING, Direct Currents from. Albert G. Davis (Illustrated description of a device for converting alternating currents into direct, and vice versa. It depends on the trigonometrical principle that the square of the sine plus the square of the cosine equals unity. 700 w.) Elec Wld—Jan. 9, 1897. No. 10,440. 15 cts.

ARC. On the Effect of Pressure in the Surrounding Gas on the Temperature of the Crater of an Electric—Correction of Results in a Former Paper. W. E. Wilson and G. F. Fritz (Researches to determine, if possible, whether the temperature of the crater in the positive carbon varies with change of pressure in the surrounding medium. 2200 w.) Elect'n—Jan. 8, 1897. No. 10,513. 30 cts.

ARMATURES, Balancing. See title "Balancing" under Mechanical Engineering, Shops and Foundry.

CATHODE RAYS, An Experiment showing the Deflection of—by a Magnetic Field. J. A. Fleming (An illustrated description or an interesting experiment. 700 w.) Elect'n—Jan. 1, 1897. No. 10,370. 30 cts.

CLARK CELLS, Variation in the Electromotive Force of—with Temperature. W. E. Ayrton and W. R. Cooper (Dials with the temperature variations and their effect upon the accuracy of this standard. 3,800 w.) Elect'n—Jan. 1, 1897. No. 10,371. 30 cts.

COAL, Electricity from—with and without Heat. Willard E. Case (A résumé of some of the efforts to solve this problem. 1,700 w.) Elec Eng—Jan. 6, 1897. No. 10,318. 15 cts.

DI-ELECTRICS, The Viscosity of Polarized (Describes a method of testing that can be applied to very viscous liquids, and reviews results that have been obtained by experimenters. 1,300 w.) Elec Rev, Lond—Jan. 15, 1897. No. 10,613. 30 cts.

EDUCATION. Electrical Engineering—Francis B. Crocker (Sketches the advance in applied electricity as representative of the changes in electrical education, the latter being moulded by the former. Prior to 1882, knowledge of the science was acquired by experience, or was self-taught. Results and criticisms of present educational methods are stated. 3,300 w.) Elec Eng—Jan. 6, 1897. No. 10,331. 15 cts.

ELECTRICAL PROBLEMS at the Chicago Cycle Show of 1897. D. Avery Kimbark (An account of the work necessary to furnish the current to light the building, furnish current for display signs, automatic apparatus, motors and general illumination for exhibitors. 5,000 w.) W Elec—Feb. 6, 1897. No. 10,908. 15 cts.

ENGINEERING, Electrical (Editorial review of the past year in Great Britain, showing a decided improvement in business over the two previous years. 3,000 w). Eng, Lond—Jan. 1, 1897. No. 10,409. 30 cts.

EXHIBITION. The Electrical Exhibition at Stuttgart, 1896 (Die Ausstellung für Electrotechnik in Stuttgart, 1896) (With illustrations of gas and petroleum motors, motor carriages, electrically driven tools, and one plate of 10-ton electric travelling crane. 5,000 w.) Zeitschr Ver Deutscher Ing—Jan. 16, 1897. No. 10,764. 20 cts.

EXPORT Trade, The Beginnings of Electrical. A. A. Knudson (Statistics claiming to be authentic, with information on the past and present condition and future possibilities. 2,800 w.) Elec Eng—Jan. 6, 1897. No. 10,325. 15 cts.

GENERATOR. A New Three-Wire Machine (Eine Neue Dreileiter Maschine). (An illustrated description of the new generator for use with the three-wire system, built by Lahmeyer, of Frankfurt-a-M. 2,500 w.) Elektrotech Rundschau—Jan. 1, 1897. No. 10,786. 15 cts.

GOVERNOR for Electrical Work, A New Steam Engine. C. Percy Taylor (Description of a new governor, which claims to fulfil the necessary conditions required in electrical work. 1,000 w.) Elect'n—Jan. 15. No. 10,606. 30 cts.

INCANDESCENT Lamps vs. Commercial Heaters. E. Y. Porter and C. D. Warner (Experiments at the University of Nebraska. A comparison of the heating effect of incandescent lamps with that of the usual form of electric heaters. 1,500 w.) Elec Eng—Jan. 20, 1897. No. 10,526. 15 cts.

INDUCTION Balance, Preliminary Trial of an Interferential. C. Barus (Describes a device capable of a variety of applications in relation to alternating currents and to magnetic induction. 3,300 w.) Am Jour of Sci—Feb., 1897. No. 10,689. 45 cts.

INDUCTION Coil, How to Make an. George T. Hanchett (Illustrated description of recent improvements. 1,500 w.) Am Elect'n—Jan., 1897. No. 10,547. 15 cts.

MAGNETIC Fields of Coils, On the. W. H. Everett (Proof of necessary formulae and some examples of their use. 2,500 w.) Elec Eng, Lond—Jan. 8, 1897. No. 10,536. 30 cts.

MAGNET, The Great Gun. W. R. King (Some measurements of the magnetic strength. Ill. 1,600 w.) Elec Rev—Feb. 3, 1897. No. 10,867. 15 cts.

MEASUREMENTS, Electrical. W. A. Anthony (Review of advances in the art of electrical measurements, the more important of which is the final establishment of the values of the fundamental electric units. 2,000 w.) Elec Eng—Jan. 6, 1897. No. 10,328. 15 cts.

MECHANICAL Construction of Electrical Machinery. See "Electrical" under Mechanical Engineering, Shop and Foundry.

METRIC System in Electrical Industries, The. F. S. Hickok (Read before the Chicago Elect. Assn. Discusses the inconvenience of multiple systems of measurement, and the effect, upon the general adoption of the metric system, of the present adoption of eight electrical units, based on the metric system of weights and measures. 2,000 w.) Elec—Jan. 20, 1897. Serial. 1st part. No. 10.533. 15 cts.

MINES, Electricity in. See title "Electricity" under Mining and Metallurgy, Mining.

PATENTS and Electrical Inventions. Henry C. Townsend (A review of the difficulties and annoyances from which electrical inventors have suffered. 1,600 w.) Elec Eng—Jan. 6, 1897. No. 10,327. 15 cts.

RADIATION. C. M. Dorman (Presidential address before the Northern Soc. of Elec Engs. Investigation of vibrations and waves and their application to electricity. 3,500 w.) Elec Eng, Lond—Jan. 22, 1897. Serial. 1st part. No. 10,856. 30 cts.

REPAIRS of Machinery. See title "Electrical Machinery," under Mechanical Engineering, Shop and Foundry.

ROENTGEN Rays, Electrification of Air by—Lord Kelvin, Dr. J. C. Beattie and Dr. Smoluchowski de Smolan (Read before the Royal Soc. of Edinburgh. Illustrated description of arrangements of the test whether or not Roentgen rays have any electrifying effect on air. 800 w.) Nature —Dec. 31, 1896. No. 10,397. 30 cts.

ROENTGEN Rays, Medicinal Properties of. William G. Caffrey (Communication to the editor claiming material benefits from treatment by these rays. 1,000 w.) Elec Wld—Jan. 9, 1897. No. 10,444. 15 cts.

SAFETY FUSES, The Reasonable Method of Rating and Testing. Frederic A. C. Perrine (Comments on the disagreement of experimenters and engineers in their understanding of the proper use of fuses in circuits, and suggests the true method of testing. 1,700 w.) Elec Wld—Jan. 30, 1897. No. 10,860. 15 cts.

SECOHMMETER as Used in the Electrical Engineering Laboratory, The. W. H. Freedman (Illustrated description of apparatus and its uses. 1,800 w.) Sch of Mines Quar—Nov., 1896. No. 10,937. 45 cts.

STORAGE BATTERY Compartments, Lining for (The method of making the batteries acid-tight and of insulating, as detailed in a communication from the Hanover Street Railway Co. 1,000 w.) Elec Eng—Jan. 6, 1897. No. 10,330. 15 cts.

SUBWAY System of Baltimore, The Proposed Municipal Electric (Brief abstract from the report of Nicholas S. Hill, Jr., Engineer of the Electrical Commission of Baltimore, which has this work in charge. This report is said to be about the best treatise in existence upon the subject of electrical subway construction and management. 1,200 w.) Eng News—Jan. 28, 1897. No. 10,666. 15 cts.

SUBWAYS, The Municipal Ownership of Electric (Discusses the question of ownership of the conduits when wires are put under ground, giving the practice in Baltimore and St. Louis, and gives some opinions as to the best system, profits, &c. 1,700 w.) Eng News—Jan. 28, 1897. No. 10,664. 15 cts.

SUBWAY Work, Progress of Electrical. William Weaver, Jr. (Illustrated description of the work, principally as carried out in New York. 1,800 w.) Elec Wld—Jan. 30, 1897. No. 10,861. 15 cts.

SUPPLY HOUSE, Past and Present, The Electrical. W. H. McKinlock (A review of the industry. 1,200 w.) Elec Eng—Jan. 6, 1897. No. 10,329. 15 cts.

SUSPENSION, On a Method of Delicate. Frank A. Laws (Calls attention of those engaged in physical work, especially electrical testing, to a device due to Dr. W. H. Julius, of Amsterdam, by which the effects of mechanical disturbance may be eliminated. 700 w.) Elec Wld—Jan. 16, 1897. No. 10,519. 15 cts.

TESLA on Electricity (His address in full on the occasion of the commemoration of the introduction of Niagara Falls power in Buffalo. Given at the Endicott Club, Jan. 12, 1897. 6,000 w.) Elec Rev.—Jan. 27, 1897. No. 10,644. 15 cts.

THEFT OF ELECTRICITY. (Diebstahl an Elektrizität) (A Discussion by Dr. Dernberg as to the legal nature of electricity as a "product," in cases of stealing current from wires for power or lighting. 2,000 w.) Elektrotech Rundschau—Jan. 15, 1897. No. 10,787. 15 cts.

VOCAL REGISTER, The Development of the Higher—by Electricity. William Harvey King (The purpose is to illustrate the action of the electrical currnet in developing the muscles of the larynx. 2,000 w.) Elec—Jan. 20, 1897. Serial. 1st part. No. 10,532. 15 cts.

WELDING, Electrical. Sydney F. Walker (Read before the Bristol Channel Center of the Inst. of Marine Engineers, in the engn'g laboratory of University College, Cardiff. The processes described are the Thomson system, Dr. Zerenor's system and the Bernardos process. 3,200 w.) Elec Eng, Lond—Jan. 8, 1897. No. 10,537. 30 cts.

WIRE and Cable Manufacture, The Improvement in. Henry A. Reed (Synopsis of the development of the insulated wire industry during the past fifteen years. 1700 w.) Elec Eng—Jan. 6, 1897. No. 10,326. 15 cts.

MARINE ENGINEERING.

BOILERS AND ENGINES.

BEARINGS of the Marine Engine, The. John Dewrance (Read before the Inst. of Marine Engs. An explanation of the way oil enables a bearing to support its load, and a discussion of the modifications in design of marine engine bearings consequent upon a right understanding of the principles of lubricatioin. 1,600 w.) Engng—Jan. 1, 1897. No. 10,403. 30 cts.

WATER TUBE Boiler, Evaporative Trials of an Almy (Report of a test made by George H. Barnes in the shops of the company at Providence, R. I. Data and results. 1,500 w.) Am Eng & R R Jour—Feb., 1897. No. 10,698. 30 cts.

WATER-TUBE Boilers. Liquid Fuel (Extracts from the Year Book of the Office of Naval Intelligence giving information on the subjects named. 2,500 w.) Am Eng & RR Jour—Feb., 1897. No. 10,697. 30 cts.

WATER-TUBE Boilers. G. L. Burton (Read before the Liverpool Eng. Soc. Abstract. Describes types and presents advantages and disadvantages. 3,200 w.) Steamship—Jan., 1897. No. 10,393. 30 cts.

NAVAL AFFAIRS.

ARMOR PLATE. See same title under Mining and Metallurgy, Iron and Steel.

MECHANISM of Our Ships of War, The (Editorial comment on the complexity of the apparatus and contrivances for manoeuvres and actions, urging attention to simplification. 1,600 w.) Eng, Lond—Jan. 8, 1897. No. 10,509. 30 cts.

"SWORDFISH" and "Spitfire," The Engines of H. M. SS. (Illustrated description of engines fitted into two torpedo-boat destroyers. Presents some novel features in the arrangement of valves. 1,600 w.) Engng—Jan. 15, 1897. No. 10,581. 30 cts.

"TERRIBLE," H. M. S. (Report of the steam trials, with details of her performance, and editorial on the facts brought out. 3,200 w.) Eng, Lond—Jan. 15, 1897. No. 10,588. 30 cts.

"TERRIBLE," The Trials of H. M. S. (Full account of the official steaming trials, with results and details. The great success of the Belleville boiler. 3,500 w.) Engng—Jan. 15, 1897. Serial. 1st part. No. 10,583. 30 cts.

TORPEDO-BOAT Destroyers "Furor" and "Terror" (Illustrated description. 15,000 w.) Engng—Jan. 1, 1897. No. 10,400. 30 cts.

MISCELLANY.

BAZIN ROLLER SHIP (Das Rollende Schiff von Bazin.) A description and illustration of this novel vessel, soon to be tried on the English Channel. 1,000 w.) Oesterr Monatschr f d Oeffent Baudienst—Jan., 1897. No. 10,780. 30 cts.

RESISTANCE of Ships. Joseph R. Oldham (Read at meeting of Civ. Engs' Club, of Cleveland, O. Part 1st is a study of the friction of solid bodies. 1,100 w.) Am Ship—Feb. 4, 1897. Serial. 1st part No. 10,895. 15 cts.

ROLLER BOAT of Mons. Bazin, The. Emile Gautier (A popular and general account of this invention, with discussion. 7,500 w.) Jour Soc of Arts—Jan. 22, 1897. No. 10,749. 30 cts.

SANITATION of Vessels. The Sanitary Arrangements of the Modern Steamship. (Die gesundheitlichen Einrichtungen der modernen Dampfschiffe, by C. Busley.) (A very complete series of articles describing the arrangements for ventilating, draining, lighting, water supply &c., of modern vessels. 3 articles. 2,500 w.) Zeitschr, d. Ver. Deutscher Ing—Jan. 2, 9, 16, 1897. No. 10,757. 60 cts.

SHIPBUILDING and Marine Engineering in 1896. (Review of the year, dealing with separate districts. Part 1st reports the Tyne, Wear, Tees, Hartlepool, Blythe and Whitby, Humber, Barrow-in-Furness, Mersey, Thames and other districts. 5,500 w.) Engng—Jan. 1, 1897. Serial, 1st part. No. 10,399. 30 cts.

SHIPBPILDING, Recent Advances in. (Review of progress in this industry. Ill. 1,700 w.) Ir & Coal Trds Rev—Jan. 29, 1897. No. 10,963. 30 cts.

SPONTANEOUS Ignition of Coal Cargoes, The. Vivian B. Lewes (Results of a long series of experiments throwing some light on the cause of this class of phenomena, with suggestions for prevention. 6,000 w.) Pro Age—Jan. 15, 1897. No. 10,484. 15 cts.

MECHANICAL ENGINEERING.

BOILERS, FURNACES AND FIRING.

BOILER-ROOM Labor, The Cost of (Information concerning the cost of labor in steam-boiler plants, taken from Circular No. 6 of the Steam Users' Assn. 700 w.) Eng News—Jan. 28, 1897. No. 10,662. 15 cts.

BOILER Progress. See same title under Architecture, Heating and Ventilation.

BUTT JOINT, A Form of Quadruple-Riveted (Illustrated description, with consideration of advantage and calculation of strength. 3,000 w.) Sta Eng—Feb., 1897. No. 10,932. 15 cts.

CHEMISTRY in the Boiler-Room. William Thompson (Shows the actual need of at least a rudimentary chemical education, and follows with a discussion of the reactions constantly taking place during com-

bustion. 1,400 w.) Can Elec News—Jan., 1897. Serial. 1st part. No. 10,359. 15 cts.

CONDUCTION in Steam Boilers, Heat. Herbert G. Geer (A discussion of the conditions on which the amount of heat conducted from one point to another depends. 1,800 w.) Power—Feb., 1897. No. 10,873. 15 cts.

EFFICIENCY and Management of Steam Boilers. E. J. Duff (Read at meeting of Manchester Assn. of Engs. Considers some of the causes which contribute to the loss of efficiency in boilers. 4.500 w.) Col Guard—Jan. 29, 1897. No. 10,954. 30 cts.

FEED-HEATER System, A New. Karl Lurdkvist (Illustrated description of trials carried out with the writer's feed-heater system, which is constructed on the principle of using both the latent and sensible heat of the steam for a more intense heating up of feed-water. 2,500 w.) Engng—Jan. 29, 1897. Serial. 1st part. No. 10,947. 30 cts.

MAN-HOLE Openings. From The Locomotive (Rules for their proper reinforcement. 1,500 w.) Bos Jour of Com—Jan. 23, 1897. No. 10,572. 15 cts.

SAFETY VALVES (Soupapes de Sureté) (Illustrated description of the Génard safety valve, an improvement on the "pop" type. 3,000 w.) La Revue Technique—Jan. 10, 1897. No. 10,772. 30 cts.

SCALE, Feed Water and Boiler (Injurious effects of scale, and its removal. 1,600 w.) Bos Jour of Com—Jan. 23, 1897. No. 10,573. 15 cts.

STACKS, A Story of. Robert Kuntsman (Considers the functions of the chimney as a means to effect economic combustion, as a conveyor of surplus products and gases, and its construction in brick or iron. 3,500 w.) St Ry Rev—Jan. 15, 1897. Serial. 1st part. No. 10,523. 30 cts.

STOKING, The Advantages of Mechanical. A. E. Outerbridge, Jr. (Historical and general comparison of mechanical stoking and hand firing, proving the practicability of complete smoke-combustion. Ill. 3,500 w.) Eng Mag—Feb., 1897. No. 10,301. 30 cts.

WATER-TUBE Boiler Construction (Illustrated description of design and construction. 1,200 w.) Mech Wld—Jan. 29, 1897. Serial. 1st part. No. 10,939. 30 cts.

WATER TUBE Boilers, A Trio of One Thousand Horse-Power (Illustrated description of the giant water tube boilers erected at the new station of the New York Steam Co. 900 w.) Sci Am—Jan. 30, 1897. No. 10,654. 15 cts.

WATER TUBE Boilers Over Other Types, Superiority of. George Shaw (Read before the Columbia Assn. of Stationary Engs. Sums up the points of superiority claimed for the water tube boiler, and discusses each point briefly. 3,000 w.) Am Mfr & Ir Wld—Jan. 22, 1897. No. 10,625. 15 cts.

WATER TUBE Boiler. See also same title under Marine Engineering, Boilers and Engines.

COMPRESSED AIR.

BELT DRIVEN Air Compressor, Richards's Automatic. (Illustrated description of a compresser designed especially for shop use or for any place where there is running shafting and where it is desirable to maintain a constant supply of compressed air without care of apparatus and at the least cost. 300 w.) Am Mach—Jan. 14, 1897. No. 10,429. 15 cts.

COMPRESSED AIR. Henry T. Hulst (Noting its increased use and diverse application. 1,600 W.) Yale Sci M—Jan., 1897. No. 10,531. 30 cts.

MINES, Use of Compressed Air in. M. Mortier (From a communication to the Societe de l'Industrie Minerale, Saint-Etienne. A review of the question whether compressed air has been turned to its fullest account as regards useful effect, or whether variations may be introduced with advantage into the method of its utilization. A summing up of the principles of this branch of mechanics. 4,000 w.) Col Guard—Jan. 22, 1897. No. 10,711. 30 cts.

MOTOR on the Elevated Railroads, New York, Compressed Air (Illustrated description of the experimental motor soon to be placed on the elevated roads, with comments and explanation of system. 1,300 w.) Sci Am—Jan. 30, 1897. No. 10,655. 15 cts.

PUMPING with the Pohle Air-Lift, Some Figures on the Cost of. George R. Murray (The cost under the system is discussed in detail, both for large and small plants. 2,200 w.) Compressed Air—Jan., 1897. No. 10,504. 15 cts.

RAILROAD SHOPS, Compressed Air in. J. J. Flather (Extracts from paper presented before the Western Ry. Club. The adaptation of compressed air to various requirements. 1,800 w.) R R Gaz—Jan. 22, 1897. No. 10,564. 15 cts.

REFRIGERATION, Compressed Air. Frank Richards (Describes, with comment, a plant employing compressed air for refrigeration. 1,200 w.) Am Mach—Jan. 21, 1897. No. 10,553. 15 cts.

SHOPS of the Atchison, Topeka and Santa Fe, Compressed Air at the (Illustrated description of the plant. 1,500 w.) R R Gaz—Jan. 15, 1897. Serial. 1st part. No. 10,460. 15 cts.

TRANSMITTING Power, Advantages of Compressed Air for. J. W. Pearse (Extracts and conclusions from a paper to the Societe de l'Industrie Minerale of France, by M. Mortier, who has made a critical study of the subject. 1,500 w.)

Compressed Air—Jan., 1897. No. 10,503. 15 cts.

USE of Compressed Air on a Great Work (Describes the service to which this power is put in the construction of the Jerome Park Reservoir for the water supply of New York City. 1,500 w.) Mfrs Record—Jan. 15, 1897. No. 10,483. 15 cts.

USES of Compressed Air, Some of the (Discussion at the Western Railway Club, December meeting, of Mr. McConnell's paper read at the Nov. meeting. 6,500 w.) R R Gaz—Jan. 15, 1897. No. 10,461. 15 cts.

ENGINES AND MOTORS.

CRANK SHAFTS, Speed Variations in. George P. Starkweather (Gives a method of discussing engine dynamics which is quite exact. 1,500 w.) Jour Fr Inst—Feb., 1897. No. 10,919. 45 cts.

ELECTRIC Lighting by Gas Engine, Cost of. See Gas Engine under Electrical Engineering, Lighting.

EXPERIMENTAL Engines at the Durham College of Science, Newcastle-upon Tyne, with Some Results from Same, The. R. I. Weighton (Part first comprises a description of the engines and their accessories, with illustrations; also editorial. 4,500 w.) Eng Lond—Jan. 22, 1897. Serial, first part. No. 10,709. 30 cts.

GAS and Oil Engines. Thomas L. Wilkinson (A review of the growth of the gas and oil engine industry, with brief history and testimony as to their efficiency and economy. 3,300 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,374. 15 cts.

GAS ENGINE, Experiments on a 160-h. p.—Driven with Producer Gas at the Bale Water Works, Switzerland, 1896 (Summarized translation, by Bryan Donkin. The trials are of value in proof that a gas engine will work well and economically on producer gas from gas-works coke. Original in Zeitscshr. des Ver. Deutsch. Ing. 2,500 w.) Jour Gas Lgt—Jan. 5, 1897. No. 10,446. 30 cts.

GAS ENGINES, Gas and Petroleum Motors at the Geneva and Berlin Exhibitions of 1896 (Die Gas und die Petroleummotoren auf der schweizerischen Landesausstellung in Genf, 1896 und auf der Berliner Gewerbeausstelling, 1896.) (With description of improvements in igniting, governing and efficiency. 8,000 w.) Zeitschr. d. Vereines Deutsch. Ing—Jan. 2, 1897. No. 10,759. 20 cts.

HIGH-PRESSURE Steam, The Promise and Potency of. R. H. Thurston (Read at N. Y. meeting of the A. S. M. E. in Dec., 1896. A study of high-pressure steam in the saturated state. The facts are in part deduced from a triple-expansion and a quadruple-expansion high-pressure engine used experimentally at Sibley College. 3,000 w.) Ind & Ir—Jan. 8, 1897. Serial, part first. No. 10,505. 30 cts.

INDICATOR, The Steam Engine (The faulty points. A series of cards is given to show some of the incorrect positions and to illustrate remarks upon the remedies to be applied. 1,700 w.) Am Elect'n—Jan., 1897. No. 10,548. 15 cts.

PUMPING Engines, Brighton Water Works (Brief illustrated description of a triple-expansion pumping engine. 900 w.) Eng Lond—Jan. 22, 1897. No. 10,708. 30 cts.

SEPARATOR, The Steam (Some of its advantages and where it should be placed. 1,200 w.) Bos Jour of Com—Feb. 6, 1897. No. 10,931. 15 cts.

SHORT-STROKE Steam Engines. J. S. Raworth (Read before the Yorkshire College Engng. Soc. Explains the construction and development of what has been named "high-speed" steam engines; considers the principles involved in engines suitable for driving machines which run at a high speed of rotation, such as dynamos, fans, centrifugal pumps, &c. 3,800 w.) Engng—Jan. 29, 1897. No. 10,949. 30 cts.

STEAM ENGINE Development (Traces the great improvements that have been made and the development from low-pressure single cylinders to the high-pressure compound. 1,300 w.) Bos Jour of Com—Feb. 6, 1897. No. 10,930. 15 cts.

POWER AND TRANSMISSION.

COMPRESSED AIR. See title "Transmitting," under Mechanical Engineering, Compressed Air.

DISTRIBUTION of Power in Workshops. See same title under Electrical Engineering, Power.

ELECTRICAL Transmission. See titles "Economics" and "Transmission," under Electrical Engineering, Power.

"FRICTION Horse Power in Factories." Samuel Webber (Notes called forth by Mr. Benjamin's paper on same subject. 1,300 w.) Mach—Feb., 1897. No. 10,865. 15 cts.

GEARING, The Limiting Velocity in Belt and Rope. George R. Bale (The proposition is stated and demonstrated. 800 w.) Prac Eng—Jan. 29, 1897. No. 10,953. 30 cts.

ROPE DRIVING Practice, European. P. M. E. (Notes in European practice in transmitting power by fibrous ropes. 1,900 w.) Power—Feb., 1897. No. 10.875. 15 cts.

SHAFTING Tables. (Tables calculated by Hans Birkholz, with explanation. 1,000 w.) Power—Feb., 1897. No. 10874. 15 cts.

WATER Under Pressure for Transmitting Power, The Use of. M. Martin (Letter to the Société de l' Industrie Minérale. Presents the advantages and defects of the deviation system, and a system almost exempt from these disadvantages. 1,300 w.) Col Guard—Jan. 8, 1897. No. 10,507. 30 cts.

SHOP AND FOUNDRY.

ALUMINUM Bronze Machinery Bearings, Experiments with. George D. Rice (Illustrated description of some practical experiments made with these bearings. 1,200 w.) Ir Age—Jan. 21, 1897. No. 10,542. 15 cts.

ANCHOR-BOLT, Repairing an. Charles A. Hague (Describes a difficult piece of work in repairing an anchor-bolt which had broken about 40 inches below the upper nut. 900 w.) Am Mach—Jan. 21, 1897. No. 10,551. 15 cts.

BALANCING Armature and Other Rotating Parts of Machinery. William Baxter, Jr. (Describes and illustrates apparatus devised by the writer to obtain greater accuracy in the balancing of armatures and also to reduce the cost of operation. 1,400 w.) Am Mach—Feb. 4, 1897. No. 10,877. 15 cts.

BELT PULLEY Made Entirely of Wrought Steel, A (Illustrated description. 500 w.) Eng News—Feb. 4, 1897. No. 10,899. 15 cts.

BENDING Drawbar Yokes, Machine for (Illustrated description. 400 w.) Loc Engng—Feb., 1897. No. 10,891. 30 cts.

CHILLED Iron; Transverse Strength of —as Affected by the Relative Directions of Stress and Chill. Asa W. Whitney (Read at meeting of Foundrymen's Assn. Summary of tests, with comparison and explanation. 2,000 w.) Ir Tr Rev—Jan. 14, 1897. No. 10,492. 15 cts.

COVERING MACHINES for Wires and Cables. V. B. (Discusses the various methods of covering and the merits of different machines. 1,100 w.) Ind Rub Wld—Feb. 10, 1897. No. 10,966. 45 cts.

D-DRILLS and Wood Reamers. John Randol (Illustrated description of tools which have almost disappeared from modern machine shops, but have acquired great importance in the production of built-up guns. 2,300 w.) Am Mach—Jan. 14, 1897. No. 10,431. 15 cts.

ELECTRICAL Machinery, Repairs of. A. R. Harris (Illustrated directions designed to make ordinary repairs of this character possible to a man of ordinary intelligence. 1,700 w.) Am Mach—Jan 14, 1897. Serial. 1st part. No. 10,430. 15 cts.

ELECTRICAL Machinery, The Mechanical Construction of. F. M. Weymouth (A consideration of some of the principles involved in the mechanical construction of a dynamo. Part 1 commences with the bedplate. 2,200 w.) Elec Eng, Lond—Jan. 1, 1897. No. 10,394. 30 cts.

FOUNDRY Practice, Niles Tool Works. Peter J. Connor (Brief illustrated description of methods. 600 w.) Mach—Feb., 1897. No. 10,863. 15 cts.

HAMMER, Notes on the. Herbert Aughtie (Enumerates and explains the principles of its action. 1,300 w.) Prac Eng —Jan. 15, 1897. No. 10,618. 30 cts.

IRON, Freaks of Foundry—Dr. A. B. Harrison (Read at meeting of W. Penna. Central Min. Inst. Some analysis of foundry iron and a series of physical tests. 1,800 w.) Am Mfr & Ir Wld—Jan. 8, 1897. No. 10,386. 15 cts.

LIGHTING the Shop. Herbert Pratt (General suggestions aiming to aid in deciding the advisability of putting in a plant for one's own electric lighting. 1,500 w.) Mach—Feb., 1897. No. 10,864. 15 cts.

MACHINE TOOLS. The Machine Tools at the Fourth Cycle Salon (Les Machines-Outils au quatriéme Salon du Cycle). An illustrated description of bicycle tools, mostly of American design. 2,500 w.) La Revue Technique—Dec. 25, 1896. No. 10,765. 30 cts.

MOULDING and Gating Steel Castings. George O. Vair (Sketches showing the dissimilarity between iron and steel moulding. 1,000 w.) Am Mach—Jan. 14, 1897. No. 10,428. 15 cts.

MIXTURES, Regulating Foundry. Thomas D. West (Read at meeting of Pittsburg Foundrymen's Assn. Information on this subject, claiming that silicon and sulphur are the cause of the difference in grades of iron. 1,300 w.) Ir Tr Rev—Jan. 28, 1897. No. 10,694. 15 cts.

PIECE-WORK vs. Day's Work. Robert Grimshaw (Shows that what might be best for one shop or set of men might prove a failure under different circumstances. 1,400 w.) RR Car Jour—Jan., 1897. No. 10,358. 15 cts.

PLANING Jobs, Special. John Randol (Shop-work with the planer is described, with illustrations of different makes of planers and explanations. 2,000 w.) Am Mach—Jan. 28, 1897. No. 10,652. 15 cts.

REAMER, Chattering. Frank Richards (A talk about reamers and the ways of curing "chattering." 1,200 w.) Am Mach—Jan. 28, 1897. No. 10,653. 15 cts.

SHOP MANAGEMENT, Six Examples of Successful. Henry Roland (Describing the piece-rate systems in use by the Baldwin Locomotive Works, the Midvale Steel Co., and William Sellers & Co. 3,400 w.) Eng Mag—Feb., 1897. No. 10,303. 30 cts.

TOOLS, Some American Machine (Illustrations and descriptions of machines built by the Newton Machine Tool Works of Philadelphia. 2,000 w.) Eng, Lond—Jan. 15, 1897. No. 10,590. 30 cts.

WHEELS, Machine-Moulded. Joseph Horner (In this series of articles it is proposed to illustrate and explain the details in the pattern and foundry work involved in wheel moulding, in their relation and application to the numerous and varied classes of gears in common use, including spur and bevel, mortise, helical, worm and angle wheels. Also different methods of moulding and their modifications. 4,700 w.) Engng—Jan. 15, 1897. Serial. 1st part. No. 10,580. 30 cts.

MISCELLANY.

AUTOMOBILISM, The Future of—in the Army (L'Avenir de l'Automobilisme dans l'Armeé) The first article of a serial discussing the influence of improvements in transportation upon military manoeuvres. 3,500 w.) La Revue Technique—Jan. 10, 1897. No. 10,782. 30 cts.

BICYCLES, Changes of Speed for. E. Hospitalier (A study of gears, examining the principal solutions of the problem so far as they have received practical sanction. 1,500 w.) Sci Am—Jan. 16, 1897. No. 10,437. 15 cts.

CAPILLARY TUBES, Viscous Flow in. R. M. Deeley and C. E. Wolff (Mathematical investigation of values in mechanics. 2,200 w.) Eng, Lond—Jan. 1, 1897. No. 10,404. 30 cts.

CHIPS, The Making of. Tecumseh Swift (Suggests a line of investigation of metals. 1,600 w.) Am Mach—Feb. 4, 1897. No. 10,878. 15 cts.

COOKING BY STEAM. The Egrot Steam Cooking Apparatus. (Les Cuisines a Vapeur Egrot.) (An illustrated description of the steam cooking apparatus used in many of the large hotels and institutions of Paris. 2,500 w.) La Revue Technique—Jan. 10, 1897. No. 10,773. 30 cts.

DRAFTING ROOM, The Decimal Index in the. H. W. Alden (Describes a system providing a simple and ready reference for drawing, and a logical pattern number which indicates the use for which the pattern was intended. 2,000 w.) Am Mach—Feb. 4, 1897. No. 10,879. 15 cts.

DYNAMOMETER, A Hydraulic (Illustrated description of a machine constructed by Prof. James D. Hoffman, of Purdue University, and of tests made with it. 1,500 w.) RR Gaz—Jan. 22, 1897. No. 10,563. 15 cts.

ELEVATOR, Duckham's Pneumatic Grain (Illustrated description of system in use on the Danube. 1,000 w.) Engng—Jan. 29,1897. No. 10,946. 30 cts.

ENERGY in Motor Cars, Storage of (Abstract of lecture by M. Marcel Desprez at the Automobile Club de France, with comments. 1,500 w.) Eng, Lond—Jan. 15, 1897. No. 10,591. 30 cts.

GOVERNOR for Electrical Work. See same title under Electrical Engineering, Miscellany.

GRAIN ELEVATOR. Travelling Elevator for Unloading Vessels. (Fahrbarer Schiffs-Elevator. (Description and illustration of elevators as arranged in Budapest, to travel on tracks along the quay. 2,000 w.) Zeitschr d Oesterr Ing u Arch Vereines—Jan. 1, 1897. No. 10,752. 15 cts.

GROOVED PLATES, The Strength of. C. E. Wolff (Shows what the results would be in the case of a perfectly elastic and a perfectly ductile plate respectively. 550 w.) Prac. Eng—Jan. 29, 1897. No. 10,952. 30 cts.

INTEGRAL CURVES. W. F. Durand (A brief presentation of the more important properties. 3,000 w.) Sibley Jour of Engng—Jan., 1897. No. 10,636. 30 cts.

INDICATOR Springs, New Method of Testing (Illustrated description. 1,100 w.) Power—Feb., 1897. No. 10,876. 15 cts.

MECHANICAL Engineering (Review of the year in Great Britain; reports the interest to have centred in the Belleville boiler and the motor car. The article is largely confined to the prospects of the motor car and review of locomotive and marine engineering progress. 4,000 w.) Eng, Lond—Jan. 1, 1897. No. 10,407. 30 cts.

REFRIGERATION. The Production of Cold. (Kälteerzeugung.) Two articles by Dr. H. Lorenz upon refrigerating machinery, treating of the theory as well as mechanical details. 10,000 w.) Zeitschr Ver Deutscher Ing—Jan. 9, 1897. No. 10,761. 40 cents.

SMOKE-WASHING Device, An Interesting (Description, with plan and elevation of the economizer, mechanical draft and smoke-washing plant recently added to the equipment of station J of the N. Y. Steam Co., located near the corner of Fifty-ninth street and Madison ave., New York. 700 w.) Eng Rec—Feb. 6, 1897. No. 10,926. 15 cts.

TESTS, The Error of Comparative. W. H. Booth (Advising Engineers to be on their guard against reasoning based on comparisons, and showing that the conclusions drawn are often incorrect. 1,500 w.) Am Mach—Jan. 21, 1897. No. 10,552. 15 cts.

MINING AND METALLURGY.

COAL AND COKE.

ACCIDENTS, Safeguards Against Danger from Gases and Falls of Coal and Roof. William Jenkins (Read at meeting of W. Penna. Central Min. Inst. Points and some safeguards as they appear to the writer. 3,000 w.) Am Mfg and Ir Wld—Jan. 15, 1897. No. 10,491. 15 cts.

CALORIFIC Power of Coal, The Determination of the. W. Nayes, M. Tuggart and W. Craver (Comparison of results obtained by the Hempel Calorimeter with those obtained from analysis and by the Berthier method. 1,300 w.) Pro Age—Jan. 15, 1897. No. 10,486. 15 cts.

COAL-CUTTING Machinery. Cyrus Robinson (Reviews papers of Messrs. Gould and Hanford and shows that system to be best which best fits the condi-

tions. 1,200 w.) Am Mfr & Ir Wld—Jan. 22, 1897. No. 10,628. 15 cts.

COAL Trade in 1896, The (Review of the year in different districts. 8,000 w.) Col Guard—Jan. 1, 1897. No. 10,413. 30 cts.

CONSTITUENTS of Coal, The Proximate (Results of investigations by a committee of the British Association. 2,500 w.) Jour of Gas Lgt—Jan. 5, 1897. No. 10,447. 30 cts.

EXPLOSIONS, Coal Dust and Colliery (Epitome of a paper entitled "The Rationale of Colliery Explosions from Coal Dust," read by Donald M. D. Stuart before the Bristol Assn. of Engrs. 1,700 w.) Jour Gas Lgt—Dec. 29, 1896. No. 10,343. 30 cts.

ECONOMICS of Coal Mining, The. Henry Louis (States the economic problem of the coal trade in England and reviews available data. 3,300 w.) Ir & Coal Trds Rev—Jan. 29, 1897. No. 10,694. 30 cts.

EQUIPMENT of Collieries, The Engineering (Calls attention to the number of industries engaged in providing for the engineering equipment. 1,000 w.) Ir & Coal Trds Rev—Jan. 29, 1897. No. 10,961. 30 cts.

EXPLOSIVES in Coal Mining (An examination of the new order issued by the Home Secretary with reference to the explosives to be used in coal mines. 2,500 w.) Min Jour—Jan. 16, 1897. Serial, first part. No. 10,594. 30 cts.

EXPLOSIVES in Belgian Collieries, The Use of. Victor Watteyne (From an official report. Gives table showing intensity of blasting for driving roads during three years in the non-fiery and the three classes of fiery mines; also the new regulations and the motive that led to their adoption. 1,800 w.) Col Guard—Jan. 29, 1897. No. 10,955. 30 cts.

GASES of the Coal Mine, Some Dangerous (Abstract of a lecture by F. Clowes. Consideration of some of the common "damps" or gases which cause danger in the coal mine, such as fire-damp, chokedamp and black-damp. 1,800 w.) Min Jour—Jan. 2, 1897. No. 10,363. 30 cts.

GERMANY, The Coal Industry of—in 1896 (Review of economic conditions, production, &c. 1,000 w.) Ir & Coal Tr Rev—Jan. 1, 1897. No. 10,365. 30 cts.

HAULING Machinery, The Improvement of. Reuben Street (Read at meeting of the W. Penna. Central Min Inst. Notices the system of rope haulage, compressed air and electricity as they appear in general use. 2,600 w.) Am Mfr & Ir Wld—Jan. 8, 1897. No. 10,388. 15 cts.

LIMIT to the Cutput of a Coal Mine? Is There an Economic. William Blackmore (Read at meeting of the Min. Soc. of Nova Scotia. The subject is discussed and suggestions indicated which seem to have a bearing upon the decision in respect to every mine. 2,500 w.) Can Min Rev—Jan., 1897. No. 10,725. 30 cts.

POWER PURPOSES in Coal Working, On the Comparative Advantages and Disadvantages of Steam, Compressed Air and Electricity for—with Special Reference to Coal-Cutting and Haulage. G. E. J. McMurtrie (After extended consideration the writer's conclusions favor electricity. 7,500 w.) Ir & Coal Trds Rev—Jan. 29, 1897. No. 10,958. 30 cts.

SAFETY LAMP, The First. William Clifford (History of its invention and the controversy between Davy and Stephenson. Reviews events which incited scientists and philanthropists to seek a safe light for fiery mines, and traces the evolution of the Davy lamps. Read before the W. Penna. Cent. Min. Inst. 4,000 w.) Col Eng—Jan., 1897. No. 10,474. 30 cts.

THIN SEAMS, Is it Profitable to Mine—of Coal by Any of the Types of Electrical Mining Machines Now in Use? (Giving the advantages of a compressed-air plant and claiming good results. 1,000 w.) Am Mfr & Ir Wld—Jan. 8, 1897. No. 10,387. 15 cts.

WORKING of Coal in Scotland, Past and Present. James Barrowman (Historical account. 3,000 w.) Ir & Coal Trds Rev—Jan. 29, 1897. No. 10,959. 30 cts.

COPPER.

COPPER MATTE Blast-Furnace Charges, The Calculation of. H. Van F. Furman (The paper has been written more for the student than for the practical metallurgist. The most important points which must be considered are stated and the calculations illustrated by examples. 3,000 w.) Sch of Mines Quar—Nov., 1896. No. 10,934. 45 cts.

NEVADA, The Copper Mines of. Dan de Quille (Brief review of what has been done in mining copper in this State, which is said to be rich in this metal. 1,800 w.) Min & Sci Pr—Jan. 23, 1897. No. 10,656. 15 cts.

NICKEL and Copper in Matte and the Recovery of the Contained Precious Metals, The Separation of. Titus Ulke (A review of the various electrolytic methods proposed. 3,300 w.) Eng & Min Jour—Jan. 30, 1897. No. 10,676. 15 cts.

GOLD AND SILVER.

AUSTRALIA, Exploration in West and South. W. Carr Boyd (Illustrated condensed account of a twelve months' exploring trip for the purpose of discovering auriferous country. 2,400 w.) Aust Min Stnd—Nov. 26, 1896. Serial. 1st part. No. 10,421. 30 cts.

BROMO-CYANIDE Process of Treatment of Gold Ores and Tailings, The (Present advantages over the ordinary

cyanide process. 1,400 w.) Aust Min Stnd—Dec. 3, 1896. No. 10,422. 30 cts.

BURMA, Notes Upon Gold Mining in. A. H. Bromly (Abstract from a paper read before the Federated Inst. of Min. Engs. Distribution and mode of occurrence of the metal, with manner of working. 1,600 w.) Min Jour—Jan. 16, 1897. No. 10,593. 30 cts.

CYANIDE Process for the Treatment of Gold Ores, The. Joseph W. Richards (The story of the rise of the commercial cyanide process is briefly told, the patented basis examined, improvements made and needed, and conditions for successful use. 4,800 w.) Jour Fr Inst—Feb., 1897. No. 10,917. 45 cts.

CYANIDE Solutions, Solvent Power of Various. A. F. Crosse (From the South African Mining Journal. Describes experiments which will prove interesting to those practically engaged in the cyanide process of gold recovery. 3,400 w.) Min Jour—Jan. 23, 1897. No. 10,719. 30 cts.

CYANIDING, Some Problems in. C. C. Longridge (Some results of experimental work undertaken to effect improvements and secure economy. 1,500 w.) Min Jour—Jan. 23, 1897. No. 10,717. 30 cts.

CRIPPLE CREEK Mining District During 1896. Charles J. Moore (Review of the year, showing a steady advance both in the quantity of ore and number of mines opened. 2,800 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,381. 15 cts.

CRIPPLE CREEK Practices, Some. Wascott (Information in reference to the milling capacity, leasing system and tunnel enterprises. 1,300 w.) Min & Sci Pr—Jan. 2, 1897. No. 10,338. 15 cts.

GOLDSMITHS' Trade Related to Wealth. See same title under Economics and Industry, Miscellany.

GOLD STEALING in the Siberian Placers. E. D. Levat (An account of the habits of theft and the system of work. 700 w.) Eng & Min Jour—Feb. 6, 1897. No. 10,913. 15 cts.

MATTE, Granulating. S. E. Brotherton (A brief article showing the advantages of granulating matte and how it is done at the American Smelter in Leadville, Col. 400 w.) Eng & Min Jour—Jan. 9, 1897. No. 10,308. 15 cts.

ORE REDUCTION in Colorado, Progress and Present Status of Methods of. H. Van F. Furman (Each metal is considered separately and the progress made is briefly traced. 3,300 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,373. 15 cts.

PELATAN-CLERICI Process at De Lamar, The (From the De Lamar Nugget. Description of the operation of this process. The theory of the treatment is the solution of the bullion in the pulp by the use of cyanide and then recovering the values by electricity. 800 w.) Min Ind & Rev—Jan. 28, 1897. No. 10,887. 15 cts.

PRECIOUS Metals, The (An estimate of the quantity in use in the world at various times, with suggestions as to what becomes of it and the use in manufactures and arts. 3,300 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,375. 15 cts.

PRODUCTION, Present and Future, Gold (Statistics show that a point has been reached in excess of any ever before attained, The causes affecting production are considered with especial reference to future probabilities. 2,000 w.) Eng & Min Jour—Jan. 9, 1897. No. 10,306. 15 cts.

REFRACTORY Low-Grade Gold Ores at the Ouro Preto Gold Mine, Brazil, Notes on the Treatment of. S. G. McCormick (Part first describes the former treatment of the ore and the present method of working, with the special local conditions. 3,000 w.) Min Jour—Jan. 23, 1897. Serial. 1st part. No. 10,715. 30 cts.

SAN MIGUEL County, Resources of. Theo. F. Van Wagenen (Interesting description of the country, deposits, value, transportation facilities, etc. 1,800 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,376. 15 cts.

SIBERIA, The Gold Placers of. E. D. Levat (The characteristics of the gold formations described, with conjecture as to their probable origin. 1,500 w.) Eng & Min Jour—Jan. 23, 1897. No. 10,559. 15 cts.

SILESIA, Gold in (Gold in Schlesien) (A discussion of the geological conditions under which gold is found in Silesia, and a comparison with those of California. 4,000 w.) Glaser's Annalen—Jan. 15, 1897. No. 10,783. 15 cts.

STAMP MILL Practices, Certain. James W. Abbott (Some details of the work. 1,400 w.) Min & Sci Pr—Jan. 2, 1897. No. 10,339. 15 cts.

TREATMENT of the Gold Ores of the Guanaco Mineral District, Desert of Atacama, Chili, Notes on the. G. M. Barber (Brief account of the difficulties encountered and the irregular and singular occurrence of the gold, with partial description of the treatment of the ore. 2,300 w.) Min Jour—Jan. 23, 1897. Serial. 1st part. No. 10,718. 30 cts.

IRON AND STEEL.

ARMOR PLATE, The Cost of American (Editorial Review of the report of Secy. Herbert and of that of Secy. Whitney in 1886, with comment. 1,500 w.) Eng News—Jan. 14, 1897. No. 10,454. 15 cts.

CARBON Content, Effect of—on the Endurance of Steel. H. K. Landis (It is shown that an increase of carbon content has a marked effect in increasing the

strength and raising the elastic limit. Tables compiled from reports for 1888, 1889 and 1894. 700 w.) Ir Tr Rev—Jan. 7, 1897. No. 10,361. 15 cts.

ELASTIC LIMIT or Yield Point? P. Kreuzpointner (The meaning of elastic limit is discussed; subsequent parts will give a study of the elasticity of steel. 2,800 w.) Ir Age—Jan. 21, 1897. Serial. 1st part. No. 10,541. 15 cts.

"FLOW" in Rolling of Steel. William Cuthill (Read before the West of Scotland Iron and Steel Inst. The operation of rolling is considered in relation to the experiments of M. Tresca upon the "flow" of solids, and the three points of speed of bar, diameter of rolls and depth of draft are studied in reference to economy of driving power of the mill. 2,200 w.)Col Guard—Jan. 22, 1897. No. 10,713. 30 cts.

FORGINGS, Steel. H. F. J. Porter (Illustrated historical review of the development of the art of forging in this country and of the circumstance leading to the erection of the Bethlehem Iron Co.'s plant; describes the processes in use there. 8,400 w.) Jour W Soc of Engs—Dec., 1896. No. 10,470. 45 cts.

HEMATITES of Alabama Geologically Considered, The. Henry McCalley (The more important ones are of Silurian formation; they are described, with statement of the advantages which have led to their remarkable development. An approximate general section of East Red Mountain, between Birmingham and Bessemer, is given. 2,000 w.) Eng & Min Jour—Jan. 9, 1897. No. 10,309. 15 cts.

IRON METHODS, Notes on Some Comparisons Between Southern and Nova Scotia. C. A. Meissner (A comparison of conditions, with special reference to price and quality. 5,500 w.) Can Min Rev—Jan., 1897. No. 10,724. 30 cts.

JAPAN, Experiments in Steel-Making in (Briefly notes the experiments, results and considerations entertained by the Japanese Government preparatory to starting a steel-making establishment. 1,800 w.) Engng—Jan. 8, 1897. No. 10,502. 30 cts.

LAKE SUPERIOR Iron Mines (Facts relating to these mines, with supplement giving the shipments for 1896 and the past forty-one years. 1,200 w.) Ir Tr Rev—Jan. 21, 1897. No. 10,619. 15 cts.

MINNESOTA Iron Mines in 1896. Horace V. Winchell (An explanation of Mesaba Range problems and their solution, and of the three methods adopted for mining these flat deposits, with a statement of the conditions for the immediate future. 2,000 w.) Ir Tr Rev—Jan. 7, 1897. No. 10,360. 15 cts.

NICKEL STEEL in Metallurgy, Mechanics and Armor. Henry W. Raymond (Reviewing the events that led up to the congressional appropriation of one million dollars for the purchase of nickel ore. 3,600 w.) Eng Mag—Feb., 1897. No. 10,304. 30 cts.

OPEN-HEARTH Steelmaking, Twelve Months' Progress in. Bernard Dawson (Review of advances made in the past year, most of which have come from the chemists rather than the engineers. 2,600 w.) Ir & Coal Trds Rev—Jan. 29, 1897. No. 10,960. 30 cts.

PHOSPHORUS in Steels, On the Influence of Heat Treatment and Carbon Upon the Solubility of. E. D. Campbell and S. C. Babcock (Contribution to the Am. Chem. Jour. from the Laboratory of Analytical Chemistry of the University of Michigan. Research undertaken to determine whether chemical evidence could be obtained to prove that phosphorus may exist in steel in at least two forms. 1,100 w.) Am Mfr & Ir Wld—Jan. 22, 1897. No. 10,626. 15 cts.

PIG-IRON as a Possible Secondary Product of the Blast-Furnace. B. H. Thwaite (Calls attention to improvements aiming to increase the power-supply, profit-earning capacities of the furnace, to an extent that will make the question of iron-making an indifferent essential. 1,500 w.) Ir & Coal Trds Rev—Jan. 29, 1897. No. 10,962. 30 cts.

PIG-IRON, Southern. See same title under Economics and Industry, Commerce and Trade.

PLATE Mills, The Bethlehem (Illustrated detailed description. 1,800 w.) Ir Age—Jan. 21, 1897. No. 10,540. 15 cts.

PRICES in 1895 and 1896, Iron and Steel (Diagram showing the course of prices in the iron and steel business during the last two years, with review of the period. 500 w.) Eng News—Jan. 14, 1897. No. 10,451. 15 cts.

PYROMETER in the Down Comer, The Value of the. Edward A. Uehling (Calls attention to the fact that an accurate record of the temperature of the waste gas of the blast-furnace is a reliable indicator of what is going on inside the furnace and of what was done in the stock-house toward keeping the furnace properly filled. 2,500 w.) Am Mfr & Ir Wld—Jan. 22, 1897. No. 10,624. 15 cts.

RAILS and Tires, Micro-Mechanical Examination of Old Steel. J. E. Stead (Paper presented to the West of Scotland Iron and Steel Inst. Results from the examination of a large number of old steel rails. 1,400 w.) Ind & Ir—Jan. 15, 1897. Serial. 1st part. No. 10,592. 30 cts.

SOUTH, and How They Are Being Developed, The Iron Mines of the. Frank G. Carpenter (Historical review of the iron industry of this country, especially in the south. 3,500 w.) Tradesman—Jan. 15, 1897. No. 10,514. 15 cts.

STRUCTURAL STEEL, Some Open Questions Concerning. Topical discussion (Six short papers on special topics, and a general discussion are given. The contributors are H. H. Campbell, Albert Ladd Colby, Frederick H. Lewis, James Christie, G. C. Henning and P. Kreuzpointner. Ill. 15,000 w.) Pro of Engs' Club of Phila—Jan., 1897. No. 10,968. 45 cts.

SULPHUR in Iron. S. S. Knight (Some remarks on the harmful results of too large quantities of sulphur. 1,200 w.) Foundry—Jan., 1897. No. 10,617. 15 cts.

TESTING of Iron and Steel, Standardizing the. P. Kreuzpointner (Showing that a test piece should be as large as practicable and geometrically proportionate. Ill. 4,800 w.) Eng Mag—Feb., 1897. No. 10,296. 30 cts.

MINING.

BLUE HEAT. (Ueber Blauwärme) (Investigating the behavior of iron at a blue heat under various tests. 7,500 w.) Glaser's Annalen—Jan. 15, 1897. No. 10,784. 15 cts.

BRITISH COLUMBIA, Notes on Some of the Mining Districts of. William Hamilton Merritt (Reports of various camps and general information showing the promise of development of mineral wealth. 1,700 w.) Eng & Min Jour—Jan. 16, 1897. No. 10,494. 15 cts.

CAGES with Movable Floor, Falling Stop Arrangement for Winding (Illustrated description, with explanation of method of working. 2,000 w.) Col Guard Jan. 1, 1897. No. 10,414. 30 cts.

COMPRESSED AIR. See title "Mines" under Mechanical Engineering, Compressed Air.

DRAINAGE of American Flat, The. Dan de Quille (Describes the location and existing conditions of American flats and the proposed extension of the Sutro drain tunnel. 1,500 w.) Min & Sci Pr—Jan. 30, 1897. Serial. 1st part. No. 10,871. 15 cts.

ELECTRICAL firing in Fiery Mines. J. von Lauer (From Oesterreichische Zeitschrift für Berg-und Hüttenwesen. Describes several different methods and the systems of firing, calling attention to the advantages. 4,000 w.) Col Guard—Jan. 22, 1897. No. 10,712. 30 cts.

ELECTRICAL POWER. See title "Mining" under Electrical Engineering, Power.

ELECTRICITY in Mines, Safe Use of. H. W. Ravenshaw (Some common causes of danger and how to guard against them. Suggestions regarding construction of electrical machinery to prevent shocks, sparks, firing of gas and other accidents. 4,000 w.) Col Eng—Jan., 1897. No. 10,477. 30 cts.

ELECTRICITY in the Mining Industry, Influence of (Illustrated review of the applications of electricity to mining and the merits which have popularized it with those who have used it in mining and milling operations. 1,500 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,377. 15 cts.

FLEUSS Breathing Apparatus as a Life-Saving Appliance, &c., for Use in Coal Mines, The Improved. George H. Winstanley (Read before the Manchester Geological Soc. Describes the apparatus and its action. 3,000 w.) Col Guard—Jan. 15, 1897. No. 10,584. 30 cts.

ILLUMINANTS Employed in the Lighting of Mines, Photometric Value of Various. A. H. Stokes (Read before the Federated Inst. of Min. Engs., England. Experiments made to determine the relative amount of light obtained from the illuminants used in mines, to define their economical value, to point out certain adjuncts used for increasing their lights and to call attention to defects and dangers which occasionally accompany their use. 3,000 w.) Am Gas Lgt Jour—Jan. 25, 1897. No. 10,609. 15 cts.

INCLINES, Crossing the Ends of the Ropes in Self-Acting. M. Combalot (From a communication to the Société de l'Industrie Minérale. States the advantage of the arrangement, difficulties to be avoided, conditions to be realized during the lift, &c., with directions for laying down an incline with the rope ends crossed. 5,300 w.) Col Guard—Jan. 15, 1897. No. 10,586. 30 cts.

MACHINE COAL Mine, An Illinois (Illustrated description of the mine, shaking screens, haulage plant, main entries, rooms, roof and machines. 2,000 w.) Eng & Min Jour—Feb. 6, 1897. No. 10,912. 15 cts.

METALLIFEROUS Mining in 1896 (Editorial review showing that, though the market has been depressed, the industry has made important progress during the year. The subject is treated in detail. 3,000 w.) Min Jour—Jan. 2, 1897. No. 10,362. 30 cts.

METAL MINING in Hungary (Describes the occurrence of gold and other metals. 800 w.) Am Mfr &Ir Wld—Jan. 29, 1897. No. 10,704. 15 cts.

MINING Sketches. Arthur Lakes (A view of the San Juan region, Col., from Engineer Mountain. A pen picture of the mountain scenery and an account of a trip with a party of experts to some mines in Mastodon and Poughkeepsie gulches and on Mineral Point. Illustrated. 1,300 w.) Col Eng—Jan., 1897. No. 10,476. 30 cts.

OIL. The Shale Oil Industry in Scotland (L'Industrie des Hailes de Schiste, Méthodes Ecossaises.) (A description of the Young-Beilby furnaces for distilling

oil and paraffin from shale. 5,000 w.) La Revue Technique—Dec. 25, 1896. No. 10,767. 30 cts.

PROMOTERS and Promoted, or, Why Mining Investments Are Generally Unprofitable. Edmund B. Kirby (Calls attention to some reasons why mining investments are often a game of chance. 3,000 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,379. 15 cts.

PYROMETER, The Le Chatelier (Das Pyrometer Von Le Chatelier.) (A description of the thermo-electric pyrometer of Le Chatelier, by means of which temperature may be accurately measured up to the melting point of platinum. 3,000 w.) Zeitschr d Oesterr Ing u Arch Vereines—Jan. 1, 1897. No. 10,751. 15 cts.

RARE METALS. The Utilization of Rare Minerals (Utilisation Industrielle des Terres Rares.) (An account of the use of minerals containing thorium for the production of Welsbach light mantles, with suggestions for the utilization of by-products. 1,000 w.) La Revue Technique—Dec. 25, 1896. No. 10,766. 30 cts.

SHAFT at the Anzin Colliery, Widening a. M. J. Prud'homme (From a letter to the northern section of the Société de l'Industrie Minérale. Gives the main lines of the project, with the principles of the methods used. 3,000 w.) Col Guard—Jan. 8, 1897. No. 10,506. 30 cts.

TUNNELS in Colorado, Some Important Mining. Thomas Tonge (Descriptive of the Bobtail, Revenue, Cowenhoven, Newhouse, United States, Pennsylvania, Knickerbocker and other mining tunnels. Ill. 3,900 w.) Eng Mag—Feb., 1897. No. 10,297. 30 cts.

VENTILATING Fan, What Is an Efficient Type of? William Clifford (Address opening the discussion at the W. Penna. Cent. Min. Inst. 1,100 w.) Am Mfr & Ir Wld—Jan. 22, 1897. No. 10,627. 15 cts.

WYOMING Mining Interests. Wilbur C. Knight (Contains reports of coal, petroleum, iron, soda, plaster, asbestos and mica. Only coal mines have been developed, but the state's resources are varied and extensive. The writer considers it reasonable to expect the discovery of valuable gold deposits, and reviews causes which have retarded the growth of the state. 2,400 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,378. 15 cts.

MISCELLANY.

EDUCATION, Technical and Mining. Regis Chauvenet (The writer considers that the value of such training is now admitted, and considers location and equipment of the institution, course and methods of instruction. 2,300 w.) Min Ind & Rev—Dec. 31, 1896. No. 10,380. 15 cts.

FLUXING Rocks of Alabama Geologically Considered, The. Henry McCalley (Describes the formation, location, &c., of the various groups, with remarks on their use. 1,400 w.) Eng & Min Jour—Jan. 30, 1897. No. 10,677. 15 cts.

FREAKS of Nature, Common. Arthur Lakes (Illustrated description of concretionary structures formed in coal, iron and other mines. 1,500 w.) Col Eng—Jan., 1897. No. 10,475. 30 cts.

FURNACE Construction and Management, Practical Notes On. Herbert Lang (The author designs to present a series of letters on every-day aspects of smelting and other branches of metal production, with the object of eliciting discussion. Part 1st deals with furnace construction. 1,800 w.) Eng & Min Jour—Jan. 23, 1897. No. 10,558. 15 cts.

GRANITE Country, The West of England. Arthur Lee (Illustrated description of these quarries and their beautiful surroundings. 1,200 w.) Stone—Jan., 1897. Serial. 1st part. No. 10,615. 30 cts.

HYDRAULIC Mines, Amount of Loss to California Due to Closure of (Considers the loss under three headings: 1st, direct loss of the gold formerly produced by the mines; 2d, depreciation in value of the property and equipment; 3d, the loss to sympathetic industries. 1,300 w.) Min & Sci Rev—Jan. 16, 1897. No. 10,549. 15 cts.

MARBLE HILLS, The Vermont. From N. Y. Post (Historical account of the quarries near Rutland and the progress of the marble industry. 2,000 w.) Stone—Jan., 1897. No. 10,616. 30 cts.

LEAD Blast Furnaces, Wall Accretions of. Malvern W. Iles (In the opinion of the writer these accretions can never be entirely prevented, but to a certain extent can be controlled. An examination of the causes and statements with reference thereto are given, with other interesting information. 1,800 w.) Sch of Mines Quar—Nov., 1896. No. 10,935. 45 cts.

METAL Markets in 1896, The London (Market reports on antimony, lead and spelter. 2,500 w.) Eng & Min Jour—Jan. 9, 1897. No. 10,307. 15 cts.

MINERAL Industry, The. (Editorial review of C. Le Neve Foster's report to the Home Office upon the mineral industries of the United Kingdom. 1,900 w.) Engng—Jan. 8, 1897. No. 10,501. 30 cts.

TINPLATE Trade in 1896, The (Records of the most unfortunate year ever known in the industry in Great Britain. 1,500 w.) Ir & Coal Tr Rev—Jan. 1, 1897. No. 10,366. 30 cts.

MUNICIPAL ENGINEERING.

GAS SUPPLY.

AMMONIA, Sulphate of,. H. H. Cousins (Part first discusses its source and manufacture, purity and impurities, annual production, &c. 1,300 w.) Jour Gas Lgt—Jan. 26, 1897. No. 10,893. 30 cts.

ASCENSION Pipes, Stopped. S. Carpenter (Observations and suggestions arising from the experience of the writer. 1,700 w.) Jour Gas Lgt—Jan. 12, 1897. No. 10,538. 30 cts.

ACETYLENE, Carbide of Calcium and (Discusses the prospects for producing acetylene at an economical rate and gives illustrations and explains the construction of various electric furnaces. 3,000 w.) Eng, Lond—Jan. 15, 1897. No. 10,587. 30 cts.

BY-PRODUCTS of Gas Works, The Nitrogenous (States the extreme gravity of the conditions of gas manufacture in England, showing how largely the commercial success depends on the returns from the by-products, and briefly examines some of the processes for the recovery of cyanogen. 2,800 w.) Eng, Lond—Jan. 22, 1897. No. 10,706. 30 cts.

GAS CONTROL from Meter to Burner. D. Macfie (Abstract of a lecture delivered in Edinburgh. Consideration of size of pipes, burners and many points of interest. 5,000 w.) Jour Gas Lgt—Jan. 19, 1897. No. 10,699. 30 cts.

HEFNER LAMPS, Influences of the Atmosphere upon the. E. Boistel (From L'Industrie Electrique. Information concerning the luminous intensity of the Hefner lamp, and of the pentone lamp having been reported, the object of the paper is to analyze these reports and make a comparison of the two standards. 4,000 w.) Pro Age—Feb. 1, 1897. No. 10,915. 15 cts.

LIGHTING Appliances, Primitive (Illustrated description of an interesting collection. Extract from article by Prof. Drehschmidt and Dr. E. Engels, in Journal für Gasbeleuchtung." 1,200 w.) Gas Wld—Jan. 2, 1897. No. 10,368. 30 cts.

MANUFACTURE and Appliances, Gas. Henry O'Connor (It is proposed to examine not only the reasons for the several steps in gas manufacture, but also the constructive details of the works, preparation of the various pieces of machinery, strength of parts, tests of apparatus, &c. 2,400 w.) Gas Wld—Jan. 2, 1897. Serial. 1st part. No. 10,367. 30 cts.

PURIFYING Material, Revivification or Regeneration of. Dr. W. Leybold (The method is described and the chemical action explained. Also manner of testing to determine whether the material is completely revivified. 1,500 w.) Pro Age—Feb. 1, 1897. No. 10,914. 15 cts.

RETROSPECT of the Year 1896, A (Review giving especial attention to the gas industry. 3,500 w.) Jour Gas Lgt—Dec. 29, 1896. No. 10,341. 30 cts.

SUPPLY, Gas (Editorial review of the past year in England. 500 w.) Eng, Lond—Jan. 1, 1897. No. 10,411. 30 cts.

TESTING Coal Gas. Norton H. Humphreys (Discusses a paper by T. Glover on the "Commercial Testing of Coal Gas." 3,800 w.) Jour Gas Lgt—Dec. 29, 1896. No. 10,342. 30 cts.

TRANSFORMATION into Alkaline Ferrocyanides of the Sulphocyanides Produced During the Manufacture of Illuminating Gas. M. Andre Dubosc (Communicated by the author to the Industrial Society of Rouen. Examines the importance of the by-products comprised under the general classification of sulpho and ferrocyanides. 1,300 w.) Am Gas Lgt Jour—Feb. 8, 1897. No. 10,920. 15 cts.

WATER GAS, A Survey of the Position of. Dr. Hugo Strache (Brief digest of an address to the chemical section of the Lower Austrian Industrial Association. Summarizes merits, recent improvements, &c. 1,800 w.) Jour Gas Lgt—Jan. 5, 1897. No. 10,448. 30 cts.

WATER GAS, Notes on Carburetted. A. G. Glasgow (Read before the Cleveland Inst. of Engs., Jan. 11, 1897. Gives history, fundamental theory, nature of process, description of apparatus, chemical and physical properties, character of flame, advantages, estimates of cost, &c. 5,000 w.) Gas Wld—Jan. 16, 1897. No. 10,602. 30 cts.

WATER GAS. The Present Status of the Water Gas Question (Der Stand der Wassergasfrage) (A strong plea for the introduction of water gas, by Dr. Hugo Strache. 2,500 w.) Wiener Bauindustrie Zeitung—Jan. 14, 1897. No. 10,763. 15 cts.

SEWERAGE.

BLANKENBERGHE, Notes on the Sewerage of (Illustrated description of a system which consists in carrying all matters into sewers and using the sewage for fertilizing the land. 2,800 w.) Eng, Lond—Jan. 1, 1897. Serial. 1st part. No. 10,405. 30 cts.

CHEMICAL Precipitation at Hamilton, Ont., Sewage, Disposal by. E. G. Barrow (Brief illustrated account of the works now being constructed. 900 w.) Eng News—Jan. 28, 1897. No. 10,667. 15 cts.

DRAINAGE as Applied to Country Houses. W. J. Wells (Read before the Inst. of Sanitary Engs. Part first presents the difficulties to be overcome in rural drainage and deals briefly with cess-

pools. 1,600 w.) San Rec—Jan. 22, 1897. No. 10,850. 30 cts.

DRAINAGE; Its Workmanship and Control. R. Thornton (Read at meeting of Staffordshire Assn. of Sanitary Inspectors. Advocates the use of the best material; discusses the fall in the drain, traps, fittings, joints, &c. 1,600 w.) San Rec—Jan. 29, 1897. Serial, 1st part. No. 10,938. 30 cts.

DRAINAGE, Rural (Briefly discusses the methods which are utilized with more or less success for the disposal of sewage; gives early use of sewers, &c. From "The Builder." 4,000 w.) Dom Engng—Jan., 1897. No. 10,746. 30 cts.

DRAINAGE Works, Delhi. B. Parkes (Part first gives a synopsis of various projects framed for the sewerage of Delhi, and plan showing route of intercepting sewer and city ditch. 1,600 w.) Ind Engng—Dec. 12, 1896. Serial, 1st part. No. 10,473. 45 cts.

RIVER-POLLUTION in England (The pollution of the Irwell and the Mersey by manufacturers and sewage discharges, and the action taken in the matter. 1,300 w.) Fire and Water—Jan. 23, 1897. No. 10,612. 15 cts.

SEWAGE DISPOSAL Works, Hamilton (Illustrated description of this efficient system. 1,500 w.) Can Eng—Jan., 1897. No. 10,482. 15 cts.

SEWAGE LIFT, Some Applications of an English (Describes and explains the use of the Adams sewage lift. Ill. 800 w.) Eng Rec—Feb. 6, 1897. No. 10,922. 15 cts.

SEWER GAS and Its Disposal. Paul Plimton (Discusses the methods that have been suggested and the need of attention to this subject. 1,100 w.) San Plumb—Feb. 1, 1897. No. 10,870. 15 cts.

SEWER GAS: Its danger to Health. Dr. Joseph Priestley (Explains the source of sewer gas and its dangers. 1,800 w.) San Rec—Jan. 8, 1897. No. 10,511. 30 cts.

SEWER SYSTEM, Peoria, Ill., West Bluff. A. D. Thompson (Illustrated detailed description of the design and construction, cost, &c. 4,800 w.) Eng News—Jan. 28, 1897. No. 10,661. 15 cts.

STREETS AND PAVEMENTS.

BRICK Paving in Small Towns. A. W. Smith (Condensed from paper read before the Indiana Engng. Soc. Advocating the use of good vitrified brick. 1,100 w.) Munic Engng—Feb., 1897. No. 10,743. 30 cts.

MOVABLE SIDEWALK. The Blot Movable Railway (Cheminde Fer à Voie Mobile, Système A. Blot. A description of plans for a travelling sidewalk for the Paris Exposition of 1900. 3,000 w.) La Revue Technique—Jan. 10, 1897. No. 10,774. 30 cts.

PAVEMENTS, Confined Rivers and the Water Supply of Ancient Rome. Francis W. Blackford (A report of the pavements of Paris, London, Rome and other foreign cities; the river walls within the cities; and a study of the ancient water supply of Rome. Ill. 4,000 w.) Jour Assn of Engng Socs—Dec., 1896. No. 10,641. 30 cts.

PAVING, German "Hit and Miss." Robert Grimshaw (Illustrated description of this form of pavement. 800 w.) Munic Engng—Feb., 1897. No. 10,741. 30 cts.

SPEEDWAY. See same title under Civil Engineering, Miscellany.

STREET-CLEANING to Good Paving, Relations of. George E. Waring, Jr. (Showing that imperfect paving greatly increases and sometimes doubles the cost of street-cleaning, and comparing the qualities of different types of pavement from the cleaner's point of view. 2,200 w.) Eng Mag—Feb. No. 10,298. 30 cts.

STREET IMPROVEMENTS, Methods of Paying for. Charles Carroll Brown (The numerous methods are classified and brief reference made to certain cities. 2,000 w.) Munic Engng—Feb., 1897. No. 10,739. 30 cts.

STREET RAIL and Its Relation to Pavements, The Modern. J. W. Howard (The kinds of rail and their effect on adjacent pavement are briefly considered. 700 w.) Munic Engng—Feb., 1897. No. 10,742. 30 cts.

TRACKS and the Pavements in New York, The Street Railway. George E. Waring, Jr. (Illustrated description of sections of rail and pavement in various parts of New York, with commendation of the track as laid in Vienna, and urging the correction in N. Y. City. 1,300 w.) Harper's Weekly—Feb. 13, 1897. No. 10,969. 15 cts.

WATER SUPPLY.

CAPACITY of Water Works in American Cities, Ownership and (Tabulated statement of cities between 50,000 and 100,000, with explanations. 700 w.) Munic Engng—Feb., 1897. No. 10,740. 30 cts.

FILTRATION Plant at Lexington, Ky., Alum Feeder for the (Illustrations and description. 700 w.) Eng News—Jan 14, 1897. No. 10,456. 15 cts.

HYDROGRAPHIC Surveys in Montana. See same title under Civil Engineering, Irrigation.

JERSEY CITY Water Contract, A Reply to the Expert Report on the Proposed (Extracts from reply by C. C. Vermeule, with remarks. 900 w.) Eng News—Feb. 4, 1897. No. 10,900. 15 cts.

JERSEY CITY Water Question, The Report of Mr. George W. Rafter on the (Special report to the Board of Trade discussing the proposed contract of the city with the East Jersey Water Co. for a

water supply. 1,100 w.) Eng Rec—Jan. 28, 1897. No. 10,598. 15 cts.

OMAHA, The Water Works Question in (Report with editorial comment. 4,800 w.) Eng Rec—Jan. 9, 1897. No. 10,335. 15 cts.

OMAHA Water Works, Facts Regarding the. Howard Mansfield (A statement called forth by an article published in this paper which the writer claims is a misrepresentation. 1,600 w.) Eng Rec—Feb. 6, 1897. No. 10,924. 15 cts.

ORGANISMS, Water Supply and Sewerage as Affected by the Lower Vegetable. Clarence O. Arey (From a paper read at Cleveland, O. The study begins with a consideration of the lowest forms of life and the subject of water supplies. 1,500 w.) Fire & Water—Jan. 9, 1897. Serial. 1st part. No. 10,372. 15 cts.

PARIS, The Water Supply of—Ite Rise and Progress (Historical particulars with valuable data, from report of chief engineer. 2,200 w.) Jour Gas Lgt—Jan. 12, 1897. Serial. 1st part. No. 10,539. 30 cts.

PUMPING SYSTEM. The Pumping Plant of the Sewerage System of Budapest (Pumpmaschinen der Budapester allgemeinen Kahallsationwerke). (A description of the high and low pressure pumping machinery for the sewerage of Budapest. 3,000 w. and 1 plate.) Zeitschr d Ver Deutscher Ing—Jan. 2, 1897. No. 10,758. 20 cts.

PURIFICATION of Water, The. Frank J. Thornbury (Discusses the various methods in common use for purifying water, showing why they are not successful. 2,500 w.) Chau—Feb., 1897. No. 10,670. 30 cts.

RESERVOIR, Greater Boston's New. Charles H. Bemis (An illustrated account of a great undertaking, the cost of which may reach $50,000,000. The dam will be nearly nine miles long, and will cover 4,195 acres to a depth of 46 feet. 2,000 w.) Harper's Weekly—Jan. 16, 1897. No. 10,356. 15 cts.

RESERVOIRS. The Control of Bodies of Water and the Action of Reservoirs in General (Die Seeretention, sowie das Wirken der Reservoire im allgemeinen A mathematical investigation of reservoirs, taking into account various rates of inflow and outflow. 6,000 w. and 1 plate.) Oesterr Monatschr f Oeffent Baudienst—Jan., 1897. No. 10,779. 30 cts.

SMALL TOWNS and Rural Districts, The Water Supply of. Percy Griffith (Extracts from a paper read at a meeting of the Soc. of Engs. Consideration of features applicable to works supplying a maximum population of 10,000. 3,000 w.) Jour Gas Lgt—Jan. 26, 1897. No. 10,894. 30 cts.

VIENNA WATER WORKS. The Pumping Station of the Vienna Water Works at Breitensee (Das Wiener Städtische Schöpfwerk in Breitensee). (A brief description of an 8,000,000 gallon pumping station, with Riedler pumps. 2,000 w.) Wiener Bauindustrie-Zeitung—Jan. 14, 1897. No. 10,762. 15 cts.

WATER FAMINE in Brooklyn, The. George E. Waring Jr. (Advises the controlling of waste, and shows that the amount wasted sometimes exceeds the amount used. 1,100 w.) Harper's Weekly—Feb. 6, 1897. No. 10,869. 15 cts.

WATER-SUPPLY (Editorial Review of the past year in Great Britain. 2,000 w.) Eng, Lond—Jan. 1, 1897. No. 10,410. 30 cts.

WATER-SUPPLY of Ancient Rome, Pavements, Confined Rivers and the. Francis W. Blackford (An account of the water supply of ancient Rome is given; also some details and technicalities of the pavements of Paris, London, Rome and other foreign cities and the well-built river walls. Ill. 4,000 w.) Jour Assn of Engng Socs—Dec., 1896. No. 10,641. 30 cts.

MISCELLANY.

FILTERING Materials, Mechanical Analysis of. Allen Hazen (Describes the manner of testing and methods of comparison, the record of results, and all details of the work. 1,800 w.) Eng Rec—Jan. 23, 1897. No. 10,599. 15 cts.

GARBAGE Disposal. H. C. Garneau (Description of process patented by Adolf Merz, of Brunn, Moravia, and in use by the St. Louis Sanitary Co. 1,500 w.) Yale Sci M—Jan., 1897. No. 10,530. 30 cts.

GLASGOW, The Atmosphere of—and Its Effects (The effects discussed are chiefly on statuary, decorations, buildings, etc. 3,000 w.) Arch, Lond—Jan. 8, 1897. No. 10,493. 30 cts.

RAILROAD AFFAIRS.

NEW CONSTRUCTION.

ELEVATION of the N. Y., N. H. and H. RR. at Boston, Mass. (Illustrated description of a costly piece of work, including construction of bridges and stations, laying of sewers and water-mains, elevation of freight yards and incidental work 2,800 w.) Eng News—Jan. 14, 1897. No. 10,450. 15 cts.

LONDON, New Railways for (Map showing the new railways for London in the several stages of progress, with interesting information concerning them. 1,800 w.) Eng Lond—Jan. 22, 1897. No. 10,707. 30 cts.

SENEGAL-NIGER Railway (Le Chemin de Fer du Sénégal au Niger). (The first of a series of articles describing the railway

now being constructed to unite the upper navigable waters of the Senegal and the Niger. 5,000 w. Map.) La Revue Technique—Jan. 10, 1897. No. 10,771. 30 cts.

TRACK ELEVATION in Jersey City, Erie (Plans showing proposed elevation of the tracks, with explanation of the situation. 1,100 w.) RR Gaz—Jan. 29, 1897. No. 10,680. 15 cts.

SYRIA, The Railway Beyreuth-Damascus-Hauran in (Description of the line, with the difficulties of construction, etc. 1,300 w.) Eng, Lond—Jan. 8, 1897. No. 10,508. 30 cts.

EQUIPMENT AND EQUIPMENT MAINTENANCE.

AIR-BRAKE System, Two-Pipe (Illustrated description of device as given by Mr. Westinghouse in his patent specifications. 1,400 w.) Loc Engng—Feb., 1897. No 10,892. 30 cts.

AXLES, Comparative Abrasion Tests of (Records of an interesting series of wearing tests on a number of car-axles conducted at the laboratory of the Cambria Iron Co. Gives results and chemical analyses. 1,000 w.) Ry Mas Mech—Jan., 1897. No. 10,350. 15 cts.

BALANCED Slide Valves for Locomotives (Editorial comment on the extensive use of this valve in America and its scant favor in England, with some explanatory reasons. 1,100 w.) Eng, Lond—Jan. 22, 1897. No. 10,710. 30 cts.

BOLSTERS, Calculating the Strength of Body and Truck (Part first considers the truck bolster only. 1,000 w.) Ry Mas Mech—Feb., 1897. No. 10,909. 15 cts.

BOX CARS, Standard Dimensions for Interchange (A table is given showing suggested standards reported to date, with editorial comment. 2,000 w.) R R Gaz—Jan. 22, 1897. No. 10,565. 15 cts.

BUFFER Blocks for Freight Equipment, Spring (Illustrated description of design from the Gould Coupler Co. 900 w.) Ry Mas Mech—Feb., 1897. No. 10,911. 15 cts.

COAL CAR, 65,000 Pounds Capacity, Double Drop-Bottom (Illustrated description of a car for heavy service, the design of C. E. Turner. 800 w.) Loc Engng—Feb., 1897. No. 10,889. 30 cts.

COMPOUND Passenger Locomotives (Editorial discussion of the value of the compound locomotive in handling fast passenger traffic. 1,200 w.) Ry Rev—Jan. 30, 1897. No. 10,723. 15 cts.

COUPLERS, Defects in M. C. B. M. J. Lorraine (Letter to the editor criticising the contour and other points. Ill. 1,500 w.) Ry Rev—Feb. 6, 1897. No. 10,941. 15 cts.

COUPLERS, Experiments on the Lateral Movement of (Diagram illustrating experiments made on the C. & N. W. Ry., with explanation. 900 w.) Ry Mas Mech—Jan., 1897. No. 10,351. 15 cts.

DOORS, Freight Car (An amusing paper by R. P. C. Sanderson, read at meeting of Southern Railway Club. 1,800 w.) Loc Engng—Feb., 1897. No. 10,890. 30 cts.

DRIVING - WHEELS, Larger (High speed in freight service has led to a reduction in the number of wheels and an enlargement in diameter on freight locomotives. 1,000 w.) R R Car Jour—Jan., 1897. No. 10,357. 15 cts.

EXPRESS LOCOMOTIVES, Some Noteworthy. George Frederick Bird (A brief history of some of the express locomotives of the past and present. Ill. 8,000 w.) Eng, Lond—Jan. 29, 1897. No. 10,957. 30 cts.

LOCOMOTIVES in England and America, Pioneer. Alfred Mathews (Descriptive of the earliest experiments in the construction and use of locomotives. Ill. 4,200 w.) Eng Mag—Feb., 1897. No. 10,300. 30 cts.

LOCOMITIVE, The Construction of a Modern. William O. Webber (Descriptive. 2,300 w.) Tradesman—Feb. 1, 1897. No. 10,727. 15 cts.

LOCOMITIVE Design, An Important Feature of (Editorial discussion of improvements needed to provide for fast passenger schedules. Gives Prof. Goss's conclusions regarding larger driving wheels and suggests lines along which to seek improvement. 2,000 w.) Ry Rev—Jan. 16, 1897. No. 10,499. 15 cts.

LOCOMOTIVE, Mogul—Vandalia Line (Illustrated description, with dimensions. 400 w.) Ry Rev—Jan. 9, 1897. No. 10,455. 15 cts.

LOCOMOTIVES, Fast Express, for the N. Y. C. & H. R. R. R. (Illustrated description, with discussion. 800 w.) Eng News—Jan. 14, 1897. No. 10,452. 15 cts.

LOCOMOTIVES, Treatment of—by Enginemen. L. D. Westfall (Calls attention to some points where a little care will save wear and repair costs, and the economy of fuel, oil, &c. 1,600 w.) Ry Mag—Jan., 1897. No. 10,647. 30 cts.

LOCOMOTIVES, New Eight-Wheel Passenger—Illinois Central Railroad (Illustrated detailed description of engine designed by William Renshaw, with dimensions. 1,400 w.) R R Gaz—Feb. 5, 1897. No. 10,906. 15 cts.

PASSENGER COACH, A Copper Sheathed (Describes a novelty in passenger car construction recently made in the shops of the N. Y., N. H. & H. RR. 900 w.) R R Gaz—Jan. 29, 1897. No. 10,682. 15 cts.

PUSHER Locomotive for the B. R. & P. Ry., Twelve-Wheel (Illustrated description of a very large engine to be used in helping coal trains over a grade of 58 ft. to the mile. Gives general dimensions. 300

w.) Eng News—Jan. 21, 1897. No. 10,554. 15 cts.

RACK RAIL Locomotives, Damascus Railway (Illustrated description. 400 w.) Eng, Lond—Jan. 15, 1897. No. 10,589. 30 cts.

ROLLING STOCK, Suggestions for Specifications for New. A. M. Waitt (From a paper read before the Western Railway Club. Calls attention to the need of careful consideration in the selection of materials, the care and inspection of equipment, &c. Editorial comment is also made. 4,500 w.) Ry Rev—Jan. 23, 1897. 10,646. 15 cts.

TRAIN, an Innovation on the Southeastern (Illustrated description of train on the American plan introduced on the Southeastern Railway of England. It is very largely patronized and will be followed by similar trains. 2,000 w.) Ry Wld—Jan., 1897. No. 10,419. 30 cts.

TRUCK, Freight—of Rolled Shapes (Illustrated description of truck designed by Mr. Pulaski Leeds. 700 w.) RR. Car Jour—Jan., 1897. No. 10,357. 15 cts.

TRUCK, The Brill "Perfect" Passenger (The object in the design was to provide additional safety against derailments, improvement in riding qualities and the relieving the wheels of stresses other than those due to the weight of the car. Illustrated description. 1,200 w.) Ry Rev—Feb. 6, 1897. No. 10,940. 15 cts.

MAINTENANCE OF WAY AND STRUCTURES.

FREIGHT STATION at Columbus, O., for the Pittsburg, Cincinnati, Chicago and St. Louis Ry., New (Illustrated detailed description. 1,000 w.) Eng News—Feb. 4, 1897. No. 10,896. 15 cts.

FROG, Spring Rail; Union Pacific Ry. (Illustrated description of design by George H. Pegram. 500 w.) Eng News—Feb. 4, 1897. No. 10,897. 15 cts.

JOINTS, Welded Rail (Editorial review of recent improvements in rail joints. 1,000 w.) Sci Am—Jan. 16, 1897. No. 10,436 15 cts.

SANDBERG Rails. A. L. Uggla (Theoretical consideration of an 80-lb. rail section adopted by the state railways in Sweden, with brief description of others whose weights are from 100 lb. to 30 lb. per yard. 1,000 w.) Engng—Jan. 29, 1897. No. 10,948. 30 cts.

SECTIONS and Weights Again, Rail (Editorial on the progress in increasing weights of rails and in the adoption of a standard section. 1,000 w.) RR Gaz—Jan. 15, 1897. No. 10,462. 15 cts.

TRAFFIC on American and Foreign Railways, The Relations of Track to. E. E. Russell Tratman (Information acquired in the course of extensive investigations of this subject is presented and discussed, with details in tabular form for comparison. 3700 w.) New York RR Club—Dec. 17, 1896. No. 10,487. 45 cts.

SIGNALLING.

ELECTRIC Interlocking System, The Taylor (Illustrates and describes an interesting installation at Edgewood, Ill., which has a number of novel features and promises success. 1,300 w.) Ry Rev—Jan. 9, 1897. No. 10,467. 15 cents.

PRACTICE in Railroad Signalling, Recent. George W. Blodgett (The progress that has been made in the last ten or twelve years and the standard practice of to-day so far as it is well established. Ill. 6,000 w.) Jour Assn of Engng Socs—Dec., 1896. No. 10,638. 30 cents.

TERMINALS AND YARDS.

BOSTON, The New Southern Terminal Station at (Considers in detail the proposed arrangement. When this is completed, all the railway traffic will be concentrated at two union stations. 3,000 w.) Eng News—Jan. 14, 1897. No. 10,455. 15 cts.

TERMINALS at Providence, R. I., The New Railway (Account of the local conditions and the problems to be solved in this work, with illustrated description. 3,000 w.) Eng News—Jan. 28, 1897. No. 10,665. 15 cts.

TRANSPORTATION.

COAL-HANDLING Machinery at Gladstone, Mich. Karl J. C. Zinck (Description of a coal-unloading and conveying machine. 700 w.) Eng News—Feb. 4, 1897. No. 10,898. 15 cts.

EARNINGS in 1896, Railroad (Comment on the reports as given in the Financial Chronicle, Dun's and Bradstreet's. 1,400 w.) R R Gaz—Jan. 22, 1897. No. 10,568. 15 cts.

CONTINENTAL Railway Facilities (Editorial asserting that nowhere is it possible for the ordinary traveller to be carried so rapidly and so cheaply as in England. The criterion adopted is the average speed over the system. Makes comparison with Continental railways. 2,000 w.) Engng—Jan. 8, 1897. No. 10,500. 30 cts.

INTERSTATE Commerce Law. Violations of the Act to Regulate Commerce. Judge Grosscup's Charge to the Jury in the Hanley Case (The charge is given in full on account of the complete statement of the law and the facts in the case. With editorial comment. 4,900 w.) Ry Rev—Jan. 16, 1897. No. 10,498. 15 cts.

MILEAGE; Locomotive—Increased by Long Runs (From a paper by C. W. Eckerson before the St. Louis Ry. Club. The writer believes there is an economy to be obtained by increasing the runs of engines and presents arguments. 2,400 w.) Ry Rev—Jan. 9, 1897. No. 10,466. 15 cts.

POOLING Bill, The (Communication

to the Committee on Interstate and Foreign Commerce, with editorial comment. 3,400 w.) Ry Rev—Feb. 6, 1897. No. 10,943. 15 cts.

MISCELLANY.

ACCIDENTS in the United States in December,Train (List of accidents for the month and their causes, with classified summary. 2,500 w.) R R Gaz—Jan. 29, 1897. No. 10,681. 15 cts.

BANKRUPTCIES in 1896, Railroad (Records of the year's foreclosures and receiverships are presented with comment. 900 w.) Bradstreet's. Jan. 9, 1897. No. 10,340. 15 cts.

BARSI Light Railway; Details of Pressed Steel Bogie (Plan and profile with mean elevation and description of the experimental line constructed near Leeds for the purpose of illustrating the method of working adopted in the Barsi Light Railway. Also illustrated description of rolling stock. 2,400 w.) Engng—Jan. 22, 1897. No. 10,705 30 cts.

BOILER PLANT Chicago Shops, C. R. I. & P. Railway (Illustrated description. 800 w.) Ry Rev—Feb. 6, 1897. No. 10,942. 15 cts.

BUDAPEST, the Railway Exhibits at the Millennial Exposition at—1896 (Das Eisenbahnwesen auf der Millenmums-Landesausstellung in Budapest, 1896) (Description of roadway and locomotives, with details of compound locomotives and plate of four-cylinder tandem compound engine. 5,000 w.) Zeitschr Ver Deutscher Ing—Jan. 9, 1897. No. 10,760. 20 cts.

CHANCES of Success, The Young Man and His. M. M. Kirkman (An outline of the conditions attending railway operation in relation to the success of young men seeking employment therein. From the Chicago World. 2,200 w.) Ry Rev—Jan. 30, 1897. No. 10,722. 15 cts.

COLLEGE COURSE, Railroading as a. R. L Donald (Relates the experience of one who has endeavored to obtain such a course. 1,400 w.) R R Gaz—Jan. 22, 1897. No. 10,562. 15 cts.

COMMISSIONERS' REPORT, Massachusetts Railroad (Extracts from report with remarks. 1,200 w.) R R Gaz—Feb. 5, 1897. No. 10,905. 15 cts.

COUPLER Decision, A Review of the Recent. Dyer Williams (The writer differs from the court in the findings and decision in the case of the Shickle, Harrison & Howard Iron Co. vs. St. Louis Coupler Co. 1,200 w.) Ry Age—Jan. 8, 1897. No. 10,364. 15 cts.

ELECTRIC Power on the B. & O., Some Results with. T. Fitzgerald (A brief review of the growth of the enterprise and a statement of its success. 900 w.) Elec Eng—Jan. 6, 1897. No. 10,312. 15 cts.

ELECTRIC TRACTION. See title "Traction Under Steam Railway Conditions," under Street and Electric Railways, Power.

LEHIGH VALLEY R. R., Annual Report of the (The results of a year which was unprofitable to nearly all the anthracite-coal carrying roads, with brief review of new lines, &c. 1,600 w.) R R Gaz—Jan. 22, 1897. No. 10,569. 15 cts.

"MIDLAND-SCOTTISH," With the. Charles Rous-Marten (An analysis of the working of this line. 2,500 w.) Eng, Lond—Jan. 29, 1897. No. 10,956. 30 cts.

NEW YORK Railroad Commissioners' Report (Review of the fourteenth annual report. 1,700 w.) R R Gaz—Jan. 15, 1897. No. 10,459. 15 cts.

PERU, the Tallest Railroad. Charles E. Lummis (An illustrated account of the remarkable railroads of Peru. 3,600 w.) Harper's Weekly—Jan. 23, 1897. No. 10,529. 15 cts.

RAPID TRANSIT Tunnel, A Brooklyn and New York (A plan for removing steam-railway traffic from the surface of Atlantic avenue and for improving rapid transit facilities. Proposes an electric line, partly elevated and partly in tunnel, with a tunnel under the East River and a terminal at Church and Cortlandt streets, New York. 1,400 w.) Eng News—Jan. 14, 1897. No. 10,453. 15 cts.

RELIEF Departments, Railway. Emory R. Johnson (Reviews their history, plan of organization, various features and results. 6,300 w.) Bul of Dept of Labor—January, 1897. No. 10,469. 45 cts.

REPORT of the Massachusetts State Board of Railroad Commissioners (Extracts from report for 1896. Treats of bicycle transportation, car ventilation and grade crossings. 4,000 w.) Eng News—Jan. 28, 1897. No. 10,663. 15 cts.

RUSSIAN Railways. W. J. M'Carroll (Illustrated description of the right of way, track, locomotives, cars, &c. 3,000 w.) Loc Engng—February, 1897. No. 10,888. 30 cts.

SLIDE RULE as an Aid to Railroad Field Work, The. George Duncan Snyder (Displays its adaptability to the numerous calculations necessary in a railroad survey. Gives the settings the author has found useful in his own work, with applications to grades, curves, transition curves, &c. 2,200 w.) R R Gaz—Jan. 22, 1897. Serial. 1st part. No. 10,566. 15 cts.

TAXATION; Methods of Taxing Railroads in the Various States (From the annual report of S. R. Billings, Railroad Commissioner of Michigan. Gives the information in condensed form. 1,800 w.) R R Gaz—Jan. 15, 1897. No. 10,464. 15 cts.

TESTING Laboratory, The C., B. & Q. (Illustrated description of the plant and work. 2,000 w.) Ry Mas Mech—Feb., 1897. No. 10,910. 15 cts.

TRACK SANDING Device for Terminal Stations (Voies Ensablées pour Gares Terminus) (Description of a device by means of which the rails may be sanded automatically by the action of the approaching train. 2,500 w.) La Revue Technique—Dec. 25, 1896. No. 10,769. 30 cts.

STREET AND ELECTRIC RAILWAYS.

GENERAL CONSTRUCTION.

BOSTON SUBWAY, Progress of the (Information gained during a recent visit, relating to the progress of this interesting work, methods, &c. Ill. 2,800 w.) Eng News—Feb. 4, 1897. No. 10,903. 15 cts.

CABLING of Edinburgh Tramways, The (Information as to the extent and nature of the scheme for changing most of the horse tramways to the cable system. 2,400 w.) Ry Wld—Jan., 1897. Serial, 1st part. No. 10.418. 30 cts.

CHALONS - SUR - MAINE, Electric Tramway at (La Traction Electrique à Chalons-sur-Maine) (A description of the opening of a new trolley road, with illustrations of cars, trolley, power-house, &c. 6,000 w.) La Revue Technique—Jan. 10, 1897. No. 10,770. 30 cts.

CLARET - VUILLEUMIER Electric Traction System, The. From "Lightning," London (Brief description of a system recently adopted in Paris, including the successful use of underground conductors. 1,600 w.) Elec Rev—Jan. 20, 1897. No. 10,-527. 15 cts.

CONCRETE Work in Detroit. F. A. Little (Facts derived from the construction of nearly fifty miles of track on a concrete foundation in Detroit. 3,000 w.) St Ry Rev—Jan. 15, 1897. No. 10,524. 30 cts.

DOUGLAS Southern Electric Tramway (An illustrated description of the latest addition to the Manx tramways. 2,800 w.) Ry Wld—Jan., 1897. No. 10,417. 30 cts.

ELEVATED RAILROADS, A Study in the Designing and Construction of—with Special Reference to the Northwestern Elevated Railroad and the Union Loop Elevated Railroad of Chicago, Ill. J. A. L. Waddell (An interesting paper, with illustrations designed to bring out an exhaustive discussion of the subject. 12,-500 w.) Pro Am Soc Civ Engs—Jan., 1897. No. 10,736. 50 cts.

GENEVA, Switzerland, The Street Railway System of (Illustrated description. 800 w.) St Ry Jour—Feb., 1897. No. 10,-729. 45 cts.

GERMAN EMPIRE, Some Electric Tramways in the (Ueber einige elektrische Bahnen im Deutschen Reiche) (An illustrated description of a number of German electric roads, both with overhead and underground conductors. 12,000 w.) Oesterr Monatschr f d Oeffent Baudienst—Jan., 1897. No. 10,777. 30 cts.

INDIA, The Trolley in—The Madras Electric Railway. George Heli Guy (Historical account of the enterprise and the difficulties, with illustrated description. 1,300 w.) Elec Eng—Jan. 6, 1897. No. 10,311. 15 cts.

LOOP, Electrical Equipment of the Union—Chicago (Illustrated description of structure being built by the Loop Construction Co., with the object of providing greatly needed terminal facilities in the downtown business district, to the four elevated railroads. 1,500 w.) W Elec—Jan. 16, 1897. No. 10,481. 15 cts.

PARIS, Electric Tramways in. A New Electric Tramway System in Paris (Un Nouveau Réseau de Tramways a Traction Electrique a Paris) (A discussion of the introduction of electric traction to provide transportation for the exposition of 1900. 3,500 w.) La Revue Technique—Dec. 25, 1896. No. 10,768. 30 cts.

RETURN, Some Further Notes on the Electric Railway. H. S. Newton (Relates experience in Syracuse in matter of railbonds, explains in detail the construction of a bond which solders fast to the rail and which seems to have solved the problem of obtaining a good return. Ill. 1,200 w.) St Ry Rev—Jan. 15, 1897. No. 10,-579. 30 cts.

STREET TRACTION in France. From N. Y. Evening Post (A brief account of systems tried in Paris. 1,300 w.) Sci Am Sup—Feb. 6, 1897. No. 10,881. 15 cts.

SUBWAY, The Boston (Part first gives the history, general conditions, map, location, types of construction, general cross sections, ventilation, water proofing, European comparisons, East Boston tunnel, Charlestown bridge, &c. 2,800 w.) Eng Rec—Jan. 23, 1897. No. 10,597. 15 cts.

SUBWAY, The Glasgow District (A few notes and impressions gleaned by a recent visit since the railway opened for public service. 2,500 w.) Ry Wld—Jan., 1897. No. 10,420. 30 cts.

EQUIPMENT.

REPAIR Shop Hints. C. B. Fairchild (Calls attention to points of frequent neglect and wrong policy in management. 2,400 w.) St Ry Jour—Feb., 1897. No. 10,732. 45 cts.

WHEEL FLANGE, The Discussion of

the Proper Shape of. C. F. Uebelacker (Demonstration of a shape of flange which present practice in track laying would call for. Diagrams. 2,000 w.) St Ry Jour—Feb., 1897. No. 10,730. 45 cts.

WHEEL TREADS and Flanges, The Irregular Wear of. H. S. Cooper (The causes and some remedies. Part first considers defects in tracks or rails, defects of wheels and defects in running gear, trucks, motors, or in adjustment of same. 4,500 w.) St Ry Jour—Feb., 1897. Serial. 1st part. No. 10,731. 45 cts.

LINE.

CONTINUOUS Rail, The Problem of the. Ward Raymond (Suggests the best time for welding; the various types of welds are described and the practice approved. 3,300 w.) St Ry Jour—Feb., 1897. No. 10,734. 45 cts.

PAVEMENTS and Street Railway Tracks. See "Tracks" under Municipal Engineering, Streets and Pavements.

SWITCHES for Electric Railways, Stationary (Stationäre Schaltanlagen für Elektrische Bahnen) (A description of the application of the switchboard system to the distribution of currents for motor purposes. 2,500 w.) Deutsche Zeitschr f Elektrotech—Jan. 15, 1897. No. 10,791. 15 cts.

UNDERGROUND Conductor with Closed Slot (Unterirdische Stromzuführung mit Verschlossenem Kanalschlitz) (The Hecker system, in which the slot has a hinged lid which is raised in sections by the car automatically. 3,000 w.) Deutsche Zeitschr f. Elektrotech—Jan. 15, 1897. No. 10,790. 15 cts.

UNDERGROUND System, the Application of Power to Street Railways, with Special Reference to the Lachmann (Die Anwendung der motorischen Kraft für Strassenbahnen, speziell unterirdische Stromzufuhrung, System Lachmann) (A comparison between the various motor systems, by the inventor of the Lachmann underground trolley. 2,500 w.) Elektrotech, Rundschau—Jan. 15, 1897. No. 10,789. 15 cts.

POWER.

COMPRESSED AIR. See title "Motor," under Mechanical Engineering, Compressed Air.

GAS Tramways. A. Lavezzari (A short description of the cars and motor and their operation in actual practice. 2,000 w.) Pro Age—Jan. 15, 1897. No. 10,485. 15 cts.

LONG RAILWAY Lines, Some Practical Suggestions for the Operation of. S. H. Short (Suggests using four smaller motors, one on each axle of the motor car, so arranged as to develop by grouping in parallel, a speed of 40 miles an hour, in series-parallel, 20 miles, and in series, 10 miles. 1,400 w.) Elec Eng—Jan. 6, 1897. No. 10,310. 15 cts.

NEW LONDON, Conn., Street Railway Co., New Power House of the (Illustrated detailed description. 2,000 w.) Elec Eng—Jan. 27, 1897. No. 10,648. 15 cts.

POWER HOUSE, Toledo Traction Company's (Illustrated detailed description. 2,500 w.) St Ry Rev—Jan. 15, 1897. No. 10,522. 30 cts.

STORAGE BATTERIES in Railway Work, The Use of. William Baxter, Jr. (Consideration of the advantages to be derived from their use. 2,800 w.) Elec Wld—Jan. 9, 1897. Serial. 1st part. No. 10,442. 15 cts.

STORAGE Battery Applied to Electric Traction. See same title under Electrical Engineering, Power.

TRACTION, Electric. Edward Barrington (Treats the subject very fully, touching on nearly every form of electric traction now in use. The paper is followed by an extended discussion. 27,800 w.) Jour W Soc of Engs—December, 1896. No. 10,471. 45 cts.

TRACTION in New York City, Competitive Systems of (Editorial review of the various systems and facts explanatory of the choice determined upon. 900 w.) Sci Am—Jan. 16, 1897. No. 10,435. 15 cts.

TRACTION on New York Street Railways, Compressed Air and Electric (Extract from the report of the Board of Railroad Commissioners of New York State for 1896, concerning the experimental trials on various lines. 600 w.) Eng News—Jan. 14, 1897. No. 10,457. 15 cts.

TRACTION Under Steam Railway Conditions, Electric. John C. Henry (The writer's convictions regarding the most desirable mechanical and electrical construction. 1,000 w.) Elec Eng—Jan. 6, 1897. No. 10,313. 15 cts.

MISCELLANY.

BROOKLYN Elevated, Annual Report of the (Review of the report and comment on projects designed to benefit the company's traffic. 1,300 w.) R R Gaz—Jan. 15, 1897. No. 10,463. 15 cents.

ELECTRIC Travel, The Age of. George Ethelbert Walsh (Explains how railroads came to develop so rapidly in this country and why electric traction has advanced. Discusses the probability of electricity taking the place of steam and the various sources of power to be developed, &c.) Chau—February, 1897. No. 10,671. 30 cts.

INCLINED PLANE Railways and Ropes. Samuel Diescher (Read at meeting of Engs. Soc of W. Penn. Describes these railways and their operation and discusses the deterioration of the wire ropes used. The history of a set of ropes is given. 5,500 w.) St Ry Jour—February, 1897. No. 10,735. 45 cts.

BOOKS OF THE MONTH

Hutton, Frederick Remsen, E. M., Ph. D., THE MECHANICAL ENGINEERING OF POWER PLANTS. First Edition. John Willey & Sons, New York. 1897. Chapman & Hall, Ltd., London, 1897. Cloth, $5.00.

A book covering this broad field, and following all that has previously been printed on the topic, needs to be an extremely well and carefully prepared treatise not to suffer by a comparison with its predecessors. Of course, not a year passes without bringing forth something new in mechanism and methods. The latest book may, therefore, always contain something not contained in prior books; but, if this be its only conspicuous merit, it may still lack sufficient justification for intrusion into the literature of applied mechanics. In our opinion, the book under present notice has very much more than this slender claim upon the approval of the mechanical public. It treats upon perhaps the most important branch of mechanical construction in a masterly, exhaustive way that cannot fail to make it a valuable addition to every mechanical library. It is not merely a text-book of mechanical construction; it is a well-indexed work of reference as well. We have sought in vain in the table and index for the name of any typical appliance, or title of any minor topic related to the general subject, that is not treated. Two prominent characteristics of the work will, we think, place it among classical engineering treatises,—to wit, its classifications, and its comparisons of advantages with disadvantages inherent in different classes of types of engines and steam appliances. The work is printed in excellent style, and contains 750 octavo pages and 500 illustrations. We can recommend it not only to constructors, but to all students of mechanical engineering.

Ricketts, Pierre de Peyster, E. M., Ph. D., and Miller, Edmund H., A. M., Ph. D. NOTES ON ASSAYING. First Edition. John Wiley & Sons, New York; Chapman & Hall, Ltd., London, 1897. Cloth, $3 00.

Designed to replace "Notes on Assaying and Assay Schemes," published in 1876, and revised in 1879.

Much more rapid quantitative determinations are now made than were practicable two decades ago, and these new methods are included in the present treatise. Many of them have been outlined in the various journals, but, before finding a place in this book, each has been tested and found successful in the assay laboratory in Columbia School of Mines. The volume also embodies the work of assaying practised in Columbia University, as organized and developed by a series of able and successful instructors and professors who have successively had charge of the laboratory. Elegantly printed and illustrated, and well indexed, the work contains 311 octavo pages.

Stephens, W. P., Yachting Editor of *Forest and Stream*, Supplement to "Small Yachts." Forest and Stream Publishing Co., New York, 1896. Cloth, $4.00.

The author has selected the best examples to illustrate the changes since the publication of "Small Yachts," and has followed the course of "limiting the subject as closely as possible to models that appeal most strongly to the amateur yacht sailor, designer, or builder as being within his personal reach." He tells us in his preface that, "although the craze of every yacht constructor has been carried to the extreme, at the same time many and important improvements have been introduced; those details and forms, such as the carrying out of all the water lines fairly to the stem band rather than ending them at the jog at the rabbit,—details which pertain rather to practical building than to designing,—have been greatly refined, and, with improved materials and methods of using them, much useless weight has been cut away, and with a positive gain in stability and speed." The yachts illustrated and described with working drawings and details of construction include many which have been sailed in American waters during the past ten years. It is claimed that great pains have been taken to secure accuracy and completeness in details and dimensions. The book is a quarto, containing 104 pages of elegantly-printed text and 63 full-page plates.

Briggs, William, M.A. LL.M., F.R.A.S., and Bryan, G. H. Sc.D., F.R.S. THE TUTORIAL STATICS. W. B. Clive, London; Hinds & Noble, New York, 1897. Cloth, $1.00.

We have previously had occasion to commend the admirable method of this excellent series of text-books in noticing other books in the course. That which will most impress the reader,—particularly if he be a trained and experienced teacher,—is the evidence of training and experience in teaching which is perceptible on every page of the several treatises. The text-book of statics, which forms an important link of the chain of works covering the subjects of mechanics, hydrostatics, dynamics, etc., includes such portions of the subject (a large portion) as may be treated without the use of the higher analytical methods. While a knowledge of trigonometry would be a help in the study of the earlier chapters of the treatise, this is not essential, as nothing more than some easily-learned trigonometrical definitions are involved. We have sought in vain among many dictionaries and treatises on physics for as clear, concise, and comprehensive definitions of terms as are given in this treatise. The definition of the term "moment" in the first paragraph on page 66 (in fifteen words), a term which many authors fail to make clear at all in a definition ten times as long, is an example in point. In short, it is the comprehension of the difficulties that students have in gaining clear conceptions of the meaning of terms that, more than anything else, manifests the skill as instructors of the authors of "The Tutorial Series." After what we have said, it is scarcely necessary to add that we most heartily commend the book, and the series of which it forms one part, to both students and instructors.

BOOKS RECEIVED.

Interstate Commerce Commission.=Preliminary Report on the Income Account of Railways in the United States for the year ending June 30, 1896. Prepared by the Statistician to the Commission. Government Printing Office, Washington, D. C. 1896. Cloth.

Report of the Commissioners of Education, 1894-95. Two volumes. Government Printing Office, Washington, D. C. Cloth.

Lee, Harry A., Commissioner of Mines. Report of Bureau of Mines, Colorado. The Smith-Brooks Printing Company, State Printers, Denver, Col. 1896. Cloth.

Irvine, R. C., Manson, Marsden, and Mande, J. L., Commissioners. Biennial Report of the Bureau of Ores for 1895 and 1896. A. J. Johnson, Superintendent State Printing, Sacramento, Cal. 1896. Cloth.

BOOKS ANNOUNCED.

Bower W. Frank. Specifications. A Practical System for Writing Specifications for Buildings. E. A. McLane, New York, 1896. Buckram, $5.00

Campbell, Harry Huse. The Manufacture and Properties of Structural Steel. Scientific Publishing Co., New York, 1896. Cloth, $4.00.

Lang, Herbert. Matte Smelting, its Principles and Later Developments. Scientific Publishing Company, New York, 1896. Cloth, $2.00.

Marshall, W. C. Course in Elementary Machine Design. The E P. Judd Company, New Haven, Conn. Cloth, $1.50.

Weisbach, Julius and Herman, Gustave. The Mechanics of Pumping Machinery. A Text Book for Technical Schools and a Guide for Practical Engineers. Translated by K. P. Dahlstrom. Macmillan Co., 1897. Cloth, $3.75.

Rickard, T. A. Stamp Milling of Gold Ores. The Scientific Publishing Company of New York announce that they will soon issue this valuable work.

Hardy, H. Stained Glass as an Art; with a Colored Reproduction of the Drawing for the Creation; 20 collotypes, illustrated from designs by Sir E. Burne-Jones, W. B. Richmond, and the author. The Macmillan Co., New York, 1897. Cloth, $6.50.

Phillips, Arthur J. A Treatise on Ore Deposits; second edition, re-written and enlarged by H. Lewis. The Macmillan Co., New York, 1897. Cloth, $7.00.

Van Ormun, J. L. Assoc. M. Am. Soc. C. E., Special University Lecturer. Topographical Surveys, their Method and Value. Bulletin of the University of Wisconsin. Engineering Series, Volume 1, Number 10. Published by authority of law and with the approval of the Regents of the University. University of Wisconsin, Madison, Wis. Paper, 35c.

Boisot, Louis, Jr. A Treatise on Mechanics' Liens. Western Publication Company, St. Paul, Minn., 1897. Cloth or sheep, $6.00.

Coleman, T. E. Sanitary House Drainage; Its Principles and Practice. A Hand Book for the Use of Architects, Engineers and Builders. Spon & Chamberlain, New York, 1897. Cloth, $2.00.

NEW CATALOGUES AND TRADE PUBLICATIONS.

These catalogues may be had free of charge on application to the firms issuing them. Please mention The Engineering Magazine when you write.

Boston Belting and Packing Company, Boston, Mass.=Leaflet illustrating and describing "Excelsior" Self-Vulcanizing Packing, for air, steam, or water joints, and "Imperial" Self-Vulcanizing Packing, a special grade for extremely hard and trying places.

The Cincinnati Milling Machine Co., Cincinnati, Ohio, U. S. A.=Elegantly-printed catalogue, illustrating and describing very fully an excellent line of milling machines, and attachments therefor, with price-lists.

The Goheen Manufacturing Co., Canton, Ohio.=Pamphlet entitled "Information on the Preservation of Iron and Steel Structures"; being extracts from a book having the same title printed under permission of the author, Mr. William Broom; to which is appended by permission of Mr. C. E. Fowler, chief engineer of the Youngstown Bridge Co., a table of data relating to the painting of iron bridges, and another table showing the cost of keeping an eighty-foot railroad bridge in first-class protection for a period of thirty-two years.

The Waterbury Farrel Foundry and Machine Company, Waterbury, Conn., U. S. A.=Leaflets (*a*) illustrating and describing rolling-mill machinery; (*b*) tube and wire-mill machinery; (*c*) price-lists of presses, drop-hammers, screw-threading machines, lathes, etc.

The H. and V. Publishing Co., New York.=Catalogue of Books selected with reference to their interest to heating and ventilating, and allied industries.

George H. Olney, Brooklyn, N. Y.=Catalogue of Model Locomotives for 1896-'97.

Cunninghame & Co., Chicago, Ill., U. S. A.=Pamphlet entitled "Coal Washing by the Luhrig Process." Reprint of a paper read before the American Society of Mechanical Engineers, by J. V. Schaefer, M. E., and other additional matter pertaining to the subject. Illustrated.

The Hoppes Manufacturing Company, Springfield, Ohio, U. S. A.=Pamphlet illustrating the Hoppes live steam feed-water purifiers, and exhaust steam feed-water heaters.

The Joseph Dixon Crucible Co., Jersey City, N. J., U. S. A.=Pamphlets (*a*) describing and setting forth the advantages of Dixon's silica graphite paint, with testimonials substantiating statements, and (*b*) a collection of testimonial letters from users during a term of twenty-five years since the silica graphite paint has been on the market.

J. C. Sala, Successor to John Roach, San Francisco, Cal.=Illustrated catalogue and manual of civil engineers' and surveyors' instruments, with useful tables, illustrations, and descriptions of the latest improvements upon instruments of precision.

The Northwest Military Academy, Highland Park, Ill., U.S.A.=Catalogue for year commencing September, 1896.

F. E. Brandeis, Brooklyn, N. Y., U. S. A.=Illustrated and descriptive catalogue and handbook of instruments of precision for civil engineers, surveyors, and astronomers. Cloth, 50c.

The Ashcroft Manufacturing Company, New York.=Catalogue (revised for 1897) illustrating and describing a long line of instruments and appliances for procuring data needed in the practice of steam engineering, such as gages, recording gages, indicators, speed recorders, alarm gages, special steam boiler safety appliances, pipe-fitters' tools, etc.

Michigan Mining School, Houghton, Miss., U. S. A.=Catalogue for 1894 to 1896, inclusive, with statements concerning the institution and its course of instruction for 1896-1898.

Buffalo Forge Co., Buffalo, N. Y., U. S. A.=Royal octavo, four-hundred-page, library-bound catalogue, brought up to 1897. Contains, also, full exposition of the Buffalo fan-system of ventilation. Profusely and richly illustrated with cuts of appliances and machines, diagrams exemplifying applications, and half-tone engravings of buildings ventilated by the Buffalo system.

The Cincinnati Corrugating Company, Piqua, Ohio.=A circular relating to the first cost, freedom from repairs, effectiveness, fire-proofing qualities, and durability of the different roofing materials now on the market. Giving much valuable information that should be in the hands of all using or handling roofing of whatsoever kind.

W. A. Crook & Bros. Co., Newark, N. J.=Catalogue for 1897, consisting of 130 pages, liberally illustrated and showing all the latest improvements in hoisting engines adapted for every purpose. The firm represents that it covers the entire field in this class of machinery.

Avondale Marble Company, Avondale, Pa., U.S.A.=Pamphlet illustrating and describing the white marble of the Avondale Marble Company, setting forth its desirable qualities for building purposes, including its beauty of texture and color, its weathering qualities and strength.

The Phosphor-Bronze Smelting Co., Philadelphia, Pa., U.S.A.=Pamphlet describing the Delta metal or bronze manufactured by this company, and largely used for propellers and other purposes where resistance to corrosion combined with strength is a desideratum.

American Steam Gauge Company, Boston, Chicago, New York.=Pamphlet illustrating and describing the line of steam gauges manufactured by this Company, the Bourdon Steam Gauge, the American-Thompson Steam Engine Indicator, Amsler's Polar Planimeter and other instruments for the measurement of pressures, temperatures and strengths of solutions, and instruments for use on steamships in obtaining data.

Anthracite Coal Operators' Association, New York.=A Trade Report giving data and statistics of this Association.

J. Jones & Son, New York.=Catalogue illustrating and describing a long line of electric supplies, with price lists.

George Focht Iron Works, Hoboken, N. J., U.S.A.=Illustrated and descriptive catalogue of self-acting apparatus for conducting and conveying coal and other materials, with price lists, etc.

Buffalo Forge Company, Buffalo, N. Y., U. S. A.=Announcement of a pocket edition size of the 400 page library bound catalogue of this Company. This book is said to contain three or four times as much data as is contained in the 1892 edition. On account of the great demand for the library edition the Company states that it has been compelled to file up requests for it until the reduced edition is ready for distribution. The text of the latter is a duplicate of the large book.

McGuire Manufacturing Co., Chicago, Ill.=Illustrated and descriptive catalogue of electric trucks, combination snow ploughs, and sweepers, street car heaters and other appliances for street railroading.

The Denver Engineering Works Company, Denver, Col., U. S. A.=Pamphlet illustrating and describing cars, gauges, skips, buckets, wheels, axles, and other allied goods for miner's use.

P. H. & F. M. Roots Company, Connorsville, Ind., U. S. A.=Illustrated catalogue of gas exhausters, gas valves, by-pass valves, automatic gas governors, pipe fittings, etc.

The Goheen Manufacturing Company, Canton, Ohio, U. S. A.=Pamphlet containing a short essay on the preservation of iron structures, and a paint table of total cost for 32 years of different kinds of paints and inclosing a piece of sheet metal painted according to the system of this company as a sample of the work done.

Ohio State University, Columbus, Ohio.=University Bulletin, giving full information in reference to the educational advantages of the institution and the qualifications necessary to be admitted thereto.

J. C. Speidel, Reading, Pa., U. S. A.=Pamphlet illustrating and describing dumb-waiters and hand-power elevators and other hoisting machinery.

Steam Users Association, Boston, Mass., U. S. A=.Pamphlet setting forth the purposes of the association, form for subscription to plans submitted, annual report and plan of work for 1897; also contains C. L. Norton's report of nonpareil cork pipe cover (supplement to circular No. 2). Circular 7 on mechanical stokers; circular 8 economizers; circular 9 combination in boiler furnaces.

The Gould's Manufacturing Co., New York.=Illustrated pamphlet containing remarks upon and capacities of Gould's electric pumps for raising water t othe upper stories of buildings.

Bangor Excelsior Slate Co., Easton, Pa., U. S. A.=Pamphlet describing the qualities of the well known Bangor Excelsior Slate for roofing purposes, with tabulated sizes of slate, the amount that should be exposed to the weather on the roof, the rule in lathing, and the number of pieces in each square.

The Northampton Works, New York.=Illustrated catalogue of dumping horse cars, sprinkling cars, etc., manufactured by Hobson & Co., Tatamy, Pa., U.S.A.

Kansas City Wheel Scraper Co., Kansas City, Mo., U.S.A.=Pamphlet illustrating and describing the Kansas City Wheel Scraper for road making.

Dry Dock Engine Works, Detroit, Mich., U. S.A.=Illustrated pamphlet describing the Howden system of hot draft.

The United Gas Improvement Co., Philadelphia, Pa.=Large illustrated quarto of 52 pages in stiff covers describing the appliances and methods of this company for the manufacture of water gas. The illustrations are unusually good and the text in connection with the cuts will give any one an excellent idea of the apparatus for manufacturing water gas.

The International Correspondence Schools, Scranton, Pa., U.S.A.=(a) Pamphlet describing the system of home study of coal and metal mining and prospecting issued by the Correspondence School of Mines (one of the schools named above) and setting forth the advantages offered by this school. (b) Pamphlet containing 1,000 testimonials from students of the International Correspondence School, Scranton, Pa., representing 74 States and countries of North America, South America, Europe, Africa and Australasia.

The Goodsell Packing Company, Chicago, Ill., U.S.A.=Illustrated and descriptive catalogue of the piston-rod packings, pump packings, etc., manufactured by this house.

American Road Machine Company, Kennett Square, Pa., U.S.A.=Illustrated pamphlet describing appliances for road making manufactured by this establishment.

The Card Electric Co., Mansfield, Ohio, U. S.A.=Large quarto pamphlet illustrating and describing the line of high grade, low speed multipolar electric machinery manufactured by this company, together with other electric appliances, regulators or resistances, controllers, etc.

Boston Belting Co., Boston, New York, Buffalo, New York, U.S.A.=Illustrated and descriptive catalogue of cotton and rubber garden hose, couplings, nozzles, couplers, sprinklers, reels and hose appliances.

The Pittsburg Boiler Scale Resolvent Co., Pittsburgh, Pa., U. S. A.=Pamphlet describing the Pittsburgh boiler scale resolvent, with price list.

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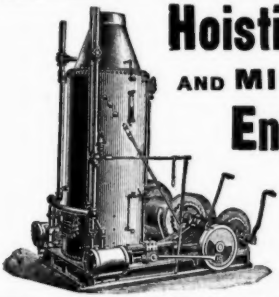

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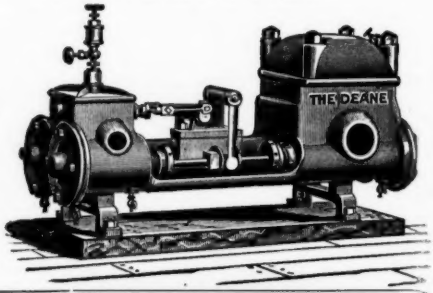

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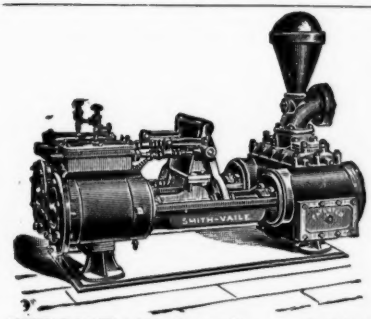

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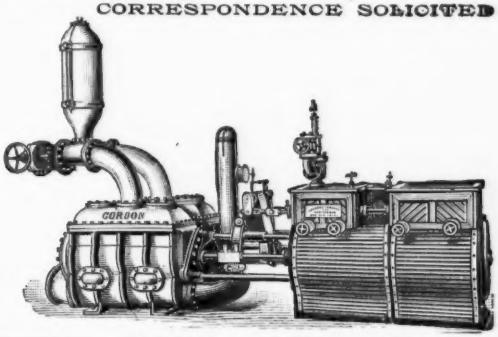

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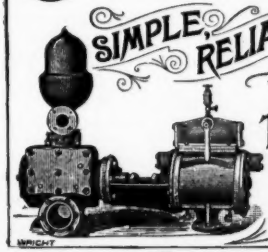

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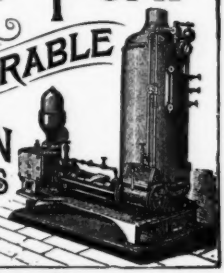

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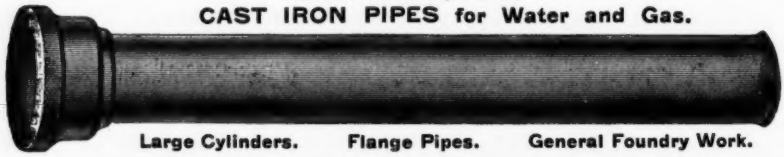

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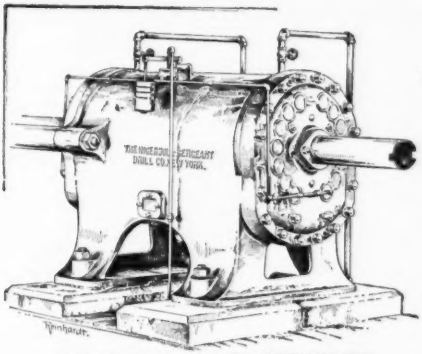

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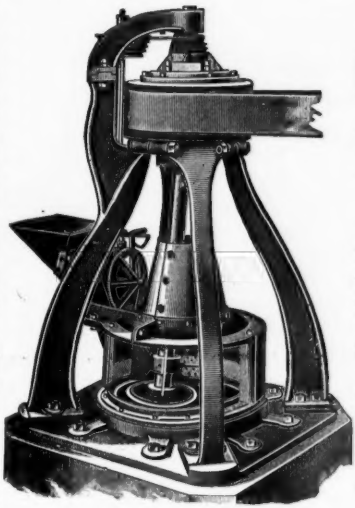

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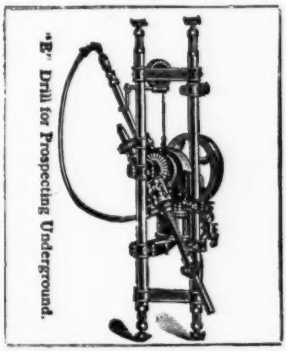

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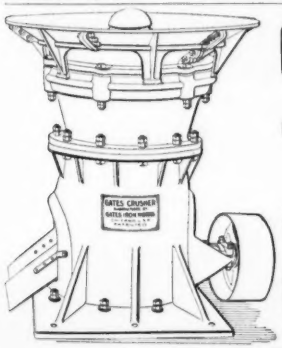

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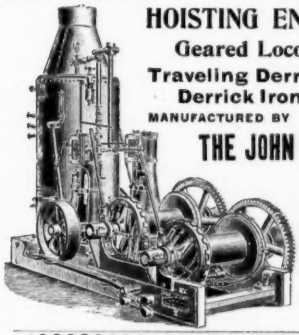

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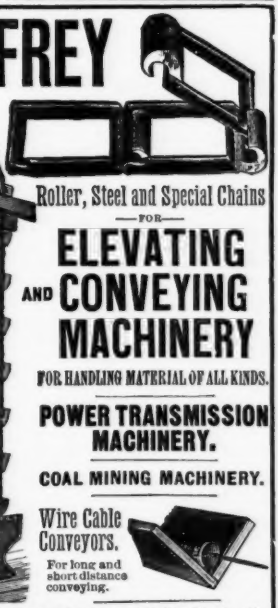

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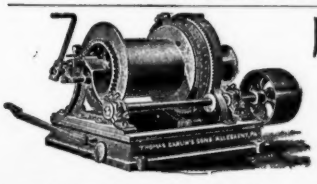

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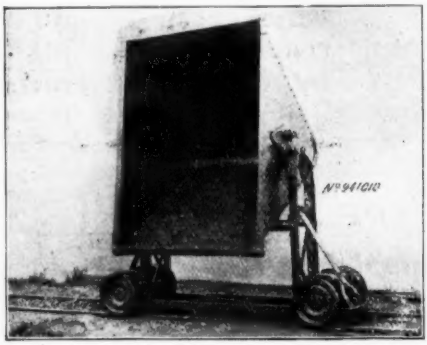

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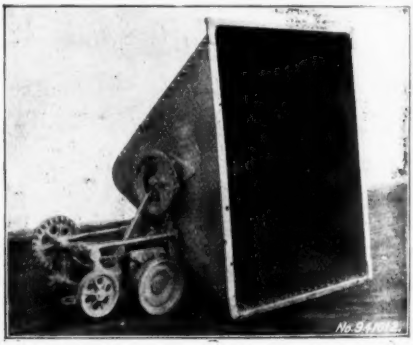

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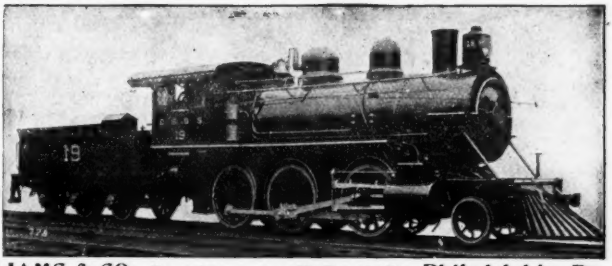

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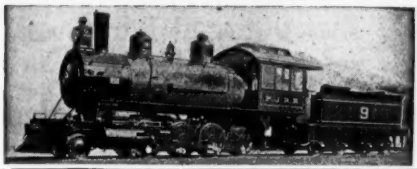

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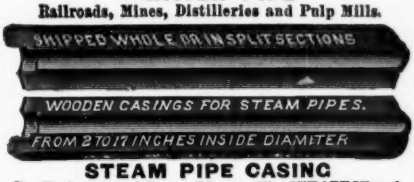

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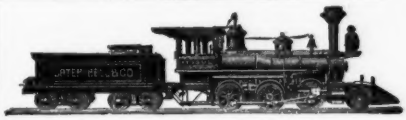

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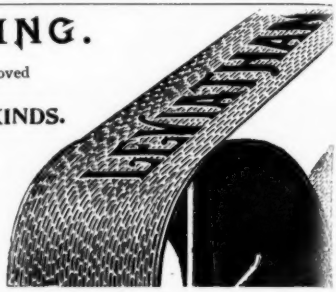

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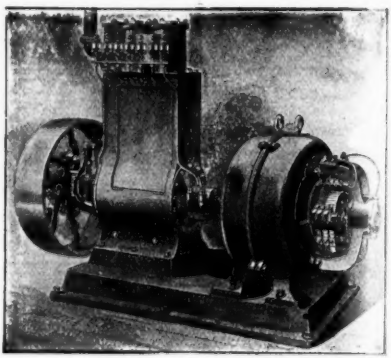

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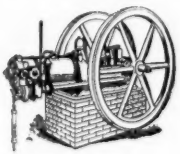

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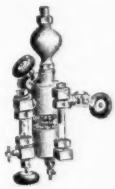

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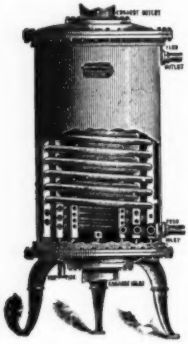

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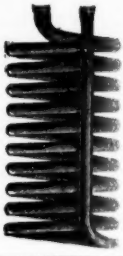

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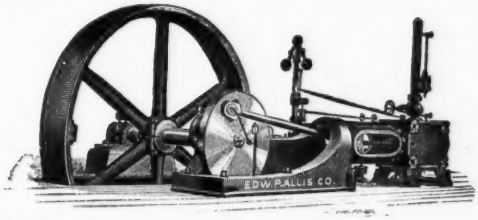

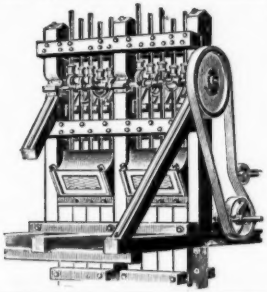

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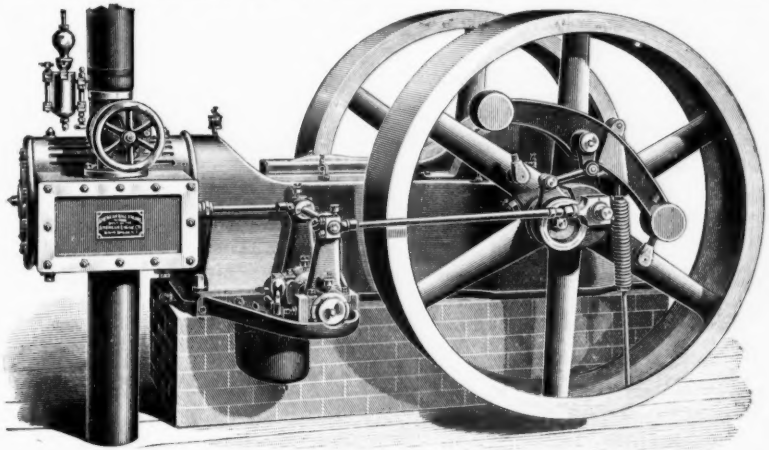

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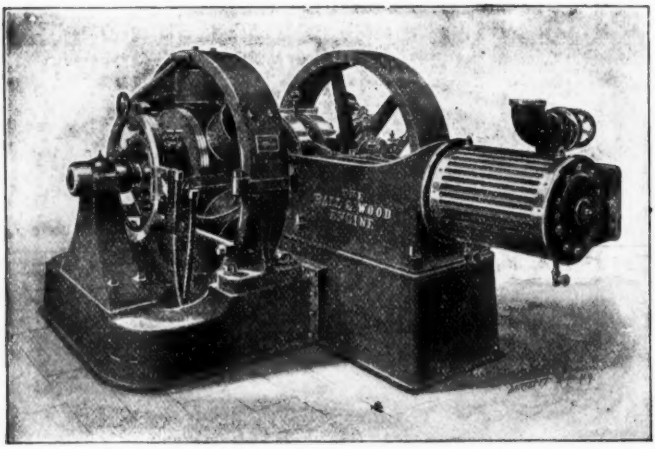

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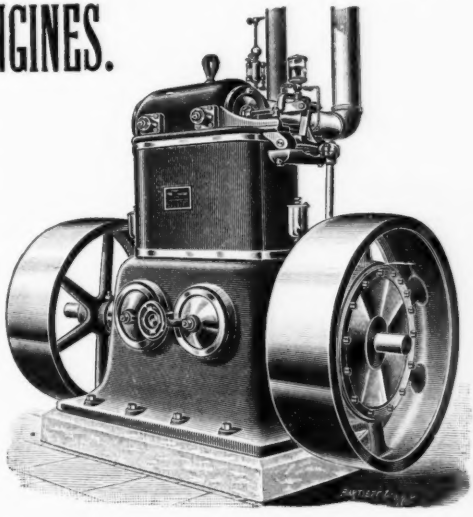

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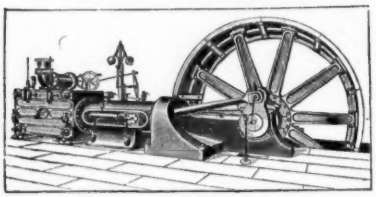

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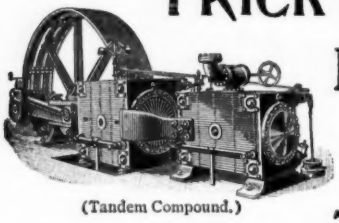

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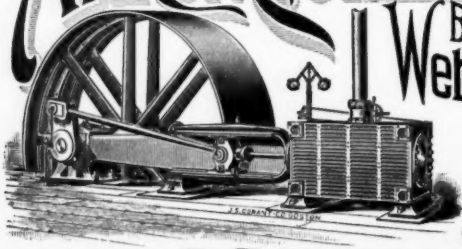

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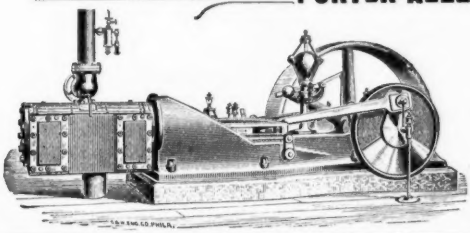

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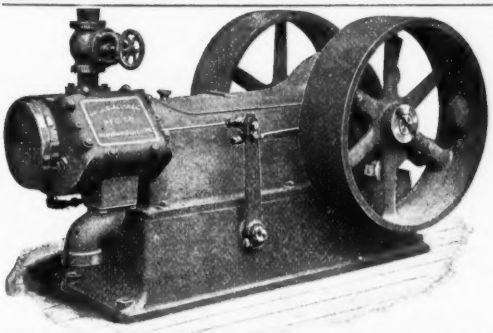

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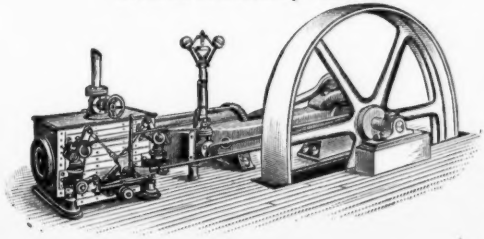

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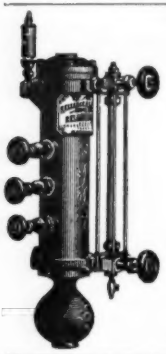

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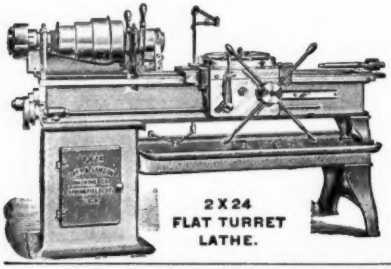

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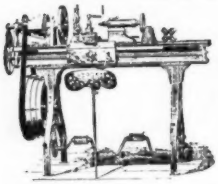

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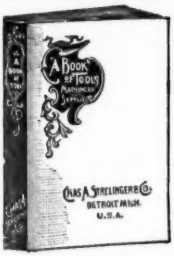

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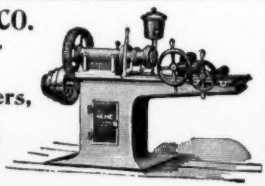

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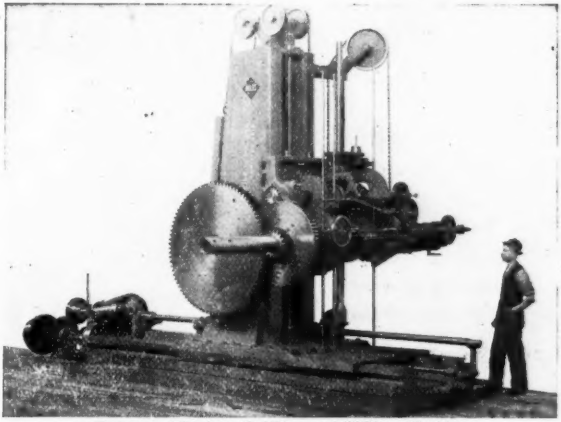

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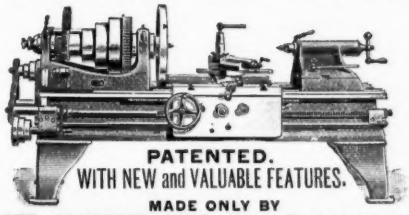

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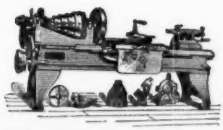

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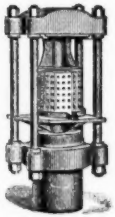

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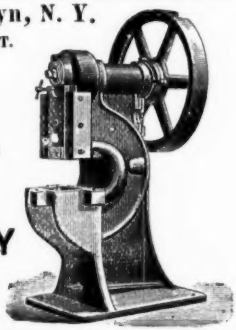

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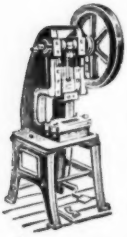

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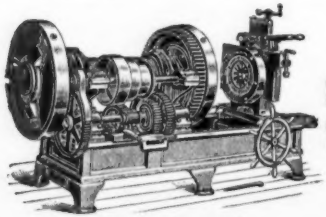

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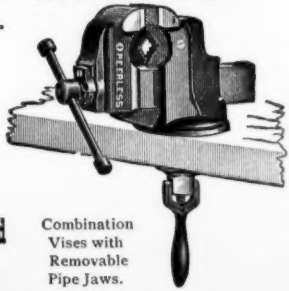

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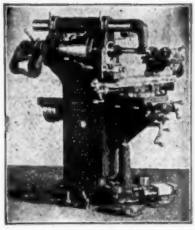

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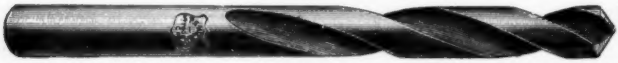

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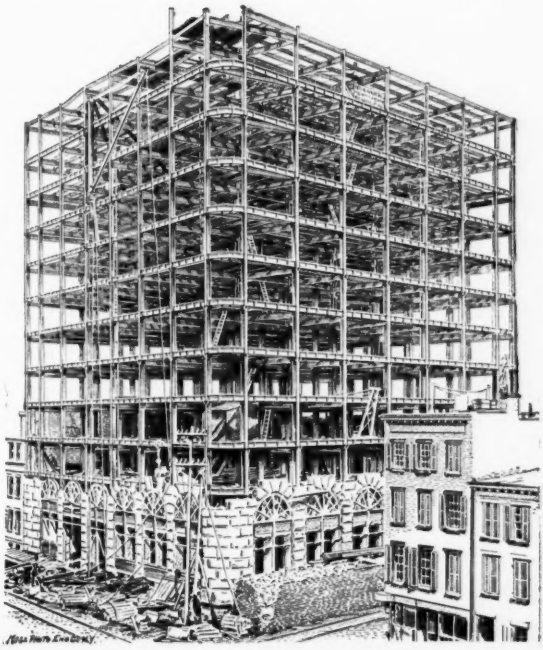

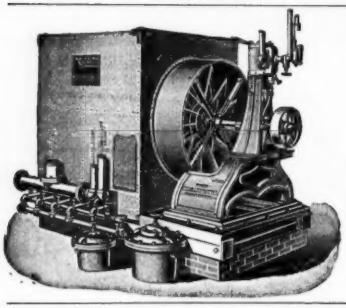

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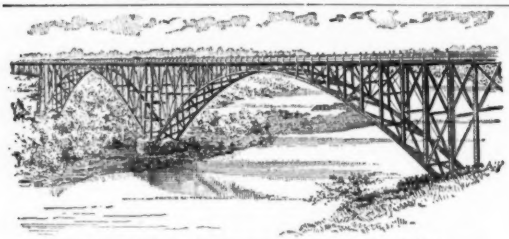

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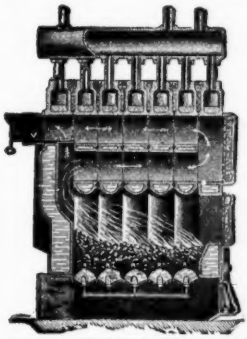

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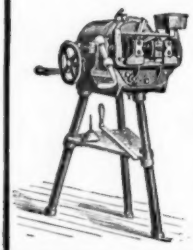

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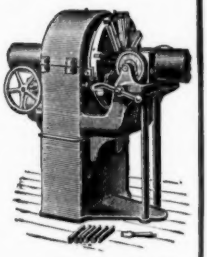

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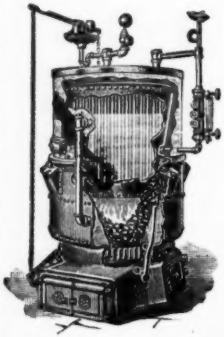

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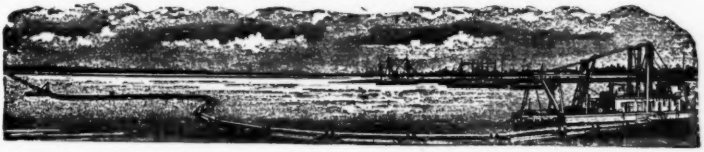

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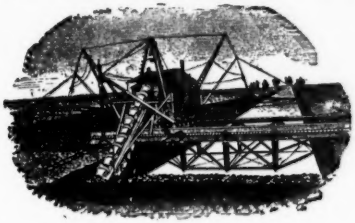

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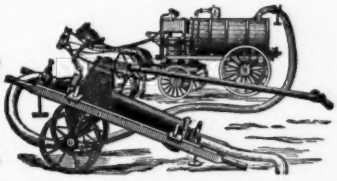

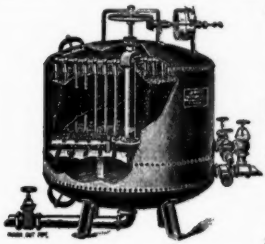

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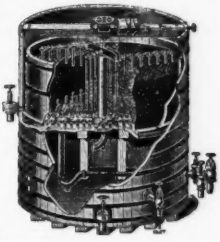

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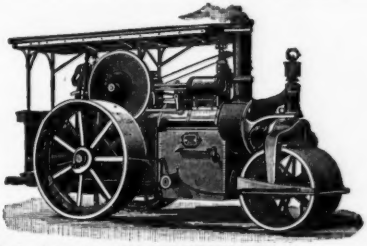

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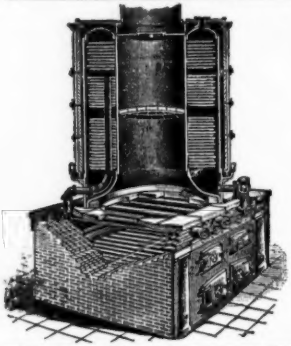

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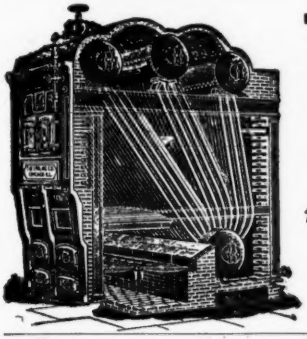

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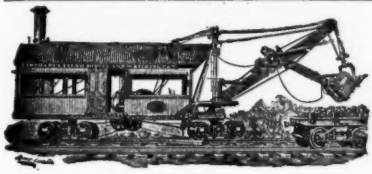

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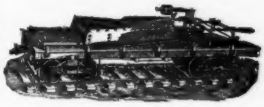

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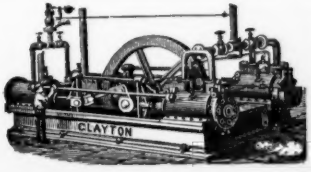

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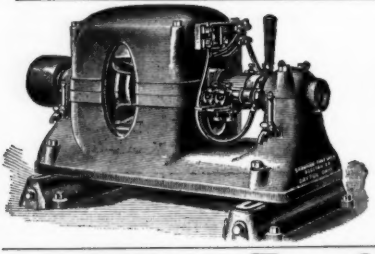

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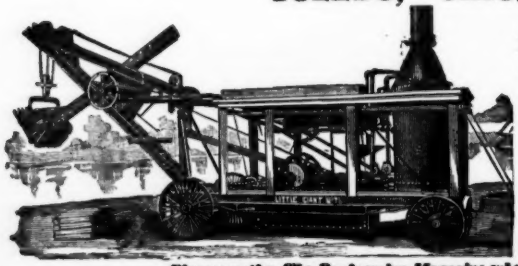

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AUTHORS AND PAPERS FOR MARCH.

JAMES H. ECKELS (*The Financial Measures Needful to Industrial Stability*)=Born at Princeton, Ill., Nov. 22, 1858; educated in the public schools of his native city, graduating from the high school in 1876; entered the Albany, N. Y., Law School in 1879, graduating therefrom in 1880 and beginning the practice of law at Ottawa, Ill., the following year. On April 3, 1893, Mr. Eckels was appointed Comptroller of the Currency by President Cleveland, and on April 28 he entered upon the discharge of the duties of the office, of which he is still the incumbent and which he has so ably and forcefully administered.

GEORGE HEBARD PAINE (*Mistakes and Improvements in Railroad Construction*)= Spent a considerable period in railroad work as a maintenance of way engineer; also for several years with a company engaged in the design and manufacture of railroad signals and signalling material, where he was employed in various capacities.

MAJOR JAMES WAITE HOWARD (*The Positive Value of Quiet and Beautiful Streets*)=Born at West Point, N. Y., shortly before the civil war; his father was then instructor in mathematics in West Point Military Academy, of which he was later in charge; graduated in classical course at Phillips Academy, Andover, Mass.; commenced practical work in railroad construction and tunneling on West Shore Railroad; subsequently finished a course of study in France; next took a course in higher mathematics and physics at the University of Göttingen, Germany; afterwards took a course of study at, and graduated as civil engineer from, Rensselaer Polytechnic Institute, Troy, N. Y.; in 1881-4 visited European cities of importance, studying features of their municipal engineering, extending his travels to Spain, Egypt and Turkey; has made a specialty of municipal engineering, and writes with authority on all topics connected therewith; at present practicing his profession in New York city; has served in the National Guard of several States, and at present holds the commission of Major in the National Guard of New Jersey, of which State he is a resident; member of a number of scientific societies.

CHARLES HENRY DAVIS, C. E. (*Comparative Economy in Electric Railway Operation*)=Consulting Engineer by profession since 1889; born 1865, Montgomery County, Penn.; educated abroad and in U. S.; entered Towne Scientific School, U. of P., 1881; entered School of Mines, Columbia College, 1883, graduating at head of class in 1887 with degree of civil engineer; 1887-89, variously with Thomson-Houston, Sawyer-Mann and Westinghouse Electric Companies in factory, construction work, and as agent; 1889 to date, in professional engineering, with offices in New York, Boston and Philadelphia, designing and building electric railways, central lighting stations, isolated plants, electric laboratory work, steel structural work, etc.;

member Am. Soc. of C. E., Am. Soc., M. E., Am. Inst., E. E., Union League, Lawyers' and Art Clubs, etc.

JAMES L. GREENLEAF (*The Times and Causes of Western Floods*) = Graduated in 1880 from the School of Mines, Columbia University, New York City; served as special agent reporting on the water-powers of the Mississippi valley and the Great Lakes, 10th U. S. Census, Vols. XVI and XVII; became an instructor in engineering in Columbia University, 1882, and later a member of the faculty; was for three years managing editor of the School of Mines Quarterly, and has contributed articles to the *Journal of the Franklin Institute*, *American Journal of Science*, and other technical publications. Since 1894, has been practicing as a civil and consulting engineer, with offices in New York City.

A. A. CARY (*The Cure for Corrosion and Scale from Boiler Waters*) = After finishing his technical course, in 1879, at the Worcester Institute of Technology, Mr. Cary spent nearly five years in the machine shop and draughting room; since then, he has been actively practicing as a mechanical engineer, making a specialty of steam-plant work. He has held several responsible positions, such as general manager and mechanical engineer of Cary & Moen, consulting engineer of the Wheeler & Wilson M'fg Co., and engineering manager of the Abendroth & Root M'fg Co.

PAUL KREUZPOINTNER (*Standardizing the Testing of Iron and Steel*) = Born at Munich, Germany; studied metallurgy at the Royal Polytechnicum, Munich; supervises the testing and examination of materials, for their physical qualities, at the testing department of the Pennsylvania Railroad at Altoona, Pa. An authority and a widely-noticed writer on the subject on the properties and strength of iron and steel in home and foreign technical journals.

J. D. GARRISON (*The Gold-Fields of the Porce River, Colombia*) = Educated at West Point; resigned from the army in 1881, entering the service of the South Penn. R.R. and remaining nearly four years as rodman, transitman, topographer, and chief of party; afterwards served about eighteen months in the War department and Interior department at Washington. Spent nearly two years as assistant engineer and assistant chief engineer of the Missouri Pacific Railway in Texas and Arkansas; nearly four years as mining engineer and acting chief engineer of the Colorado Coal and Iron Co.; nearly two years as principal assistant to Mr. Shunk on the Intercontinental Railway; about eighteen months as chief of the computing division of the Supervising Architect's office, Washington, D. C., and about eighteen months as inspector of public buildings under the same office, which position he now holds.

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WILLIAM M. SCANLAN (*Materials and Methods in Fire-Proof Construction*) = A native of Massachusetts; educated in the Boston public schools; began in 1879 the study and practice of mill engineering, under Edward Sawyer, C. E., of Boston; spent two years, 1886-7, with Ernest W. Bowditch, of Boston, in the practice of sanitary and landscape engineering; spent three years, 1888, 1889, and 1890, as architectural engineer for a Boston firm of architects. During 1891-2, was engaged as manager of construction in building the Equitable Insurance Company's building at Denver, Colo. Is at present the engineer of the Lee Construction Company of New York, and as such has made a special study of fireproof construction.

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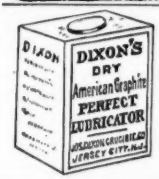

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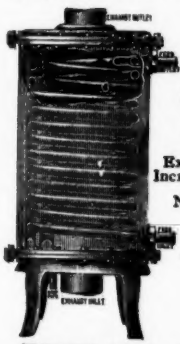

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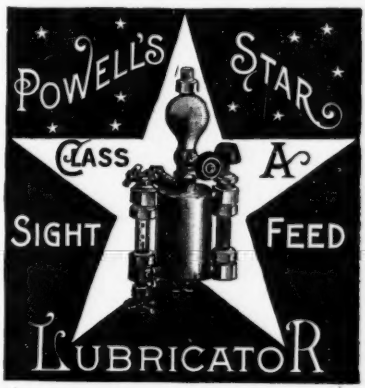

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Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co. Columbus, Ohio.
New York Central Iron Works Co., Geneva, N. Y.

Bridge Builders.

Berlin Iron Bridge Co., East Berlin, Conn.
The Continental Iron Works, Brooklyn, N. Y.
Passaic Rolling Mill Co., Paterson, N. J.
Wrought Iron Bridge Co., Canton, Ohio.

Builders' Elevators.

John F. Byers Machine Co , Ravenna, Ohio.
Lidgerwood Mfg. Co., 96 Liberty St., N. Y.

Building Materials.

Berlin Iron Bridge Co., East Berlin, Conn.
T. H. Brooks & Co., Cleveland, Ohio.
Cincinnati Corrugating Co., Piqua, Ohio.
Detroit Graphite Mfg. Co., Detroit, Mich.
Edward Smith & Co., 45 Broadway, New York.
Henry Maurer & Son, 420 E. 23d St., N. Y.
Joseph Dixon Crucible Co., Jersey City, N. J.
E. J. Johnson & Co., 36 Park Row, New York.
Merchant & Co., Inc., Philadelphia, Pa.
Pancoast Ventilator Co., Inc., Philadelphia, Pa.
Passaic Rolling Mill Co., Paterson, N. J.
N. & G. Taylor Co., Philadelphia, Pa.
Winslow Bros. Co., Chicago, Ill.
Wrought Iron Bridge Co., Canton, Ohio.

Cable Railways.

Robert Poole & Son Co., Baltimore, Md.

Cable Railway Driving Machinery.

Edw. P. Allis Co., Milwaukee, Wis.
Robt. Wetherill & Co., Chester, Pa.

Cables, Electric and Submarine.

The Okonite Co., Ltd., 253 Broadway, N. Y.

Cableways.

Lidgerwood Mfg. Co., 96 Liberty St., N. Y.

Cables, Wire.

Cooper, Hewitt & Co., 17 Burling Slip, N. Y.
H. Channon Company, Chicago, Ill.
John A. Roebling's Sons Co., Trenton, N. J.
Trenton Iron Co., Trenton, N. J.

Calcining and Drying Machines.

F. D. Cummer & Son Co., Cleveland, Ohio.

Cams and Tappets.

Chrome Steel Works, Brooklyn, N. Y.

Car Shop Machinery.

J. A. Fay & Co., Cincinnati, Ohio.
The Egan Co., Cincinnati, Ohio.

Carriage and Wagon Machinery.

Buffalo Forge Co., Buffalo, N. Y.
The Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.
Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Castings, Iron and Steel.

Edw. P. Allis Co., Milwaukee, Wis.
Brown & Sharpe Mfg. Co., Providence, R. I.
Berlin Iron Bridge Co., East Berlin, Conn.
Buffalo Forge Co., Buffalo, N. Y.
Chrome Steel Works, Brooklyn, N. Y.
Filer & Stowell Co., Milwaukee, Wis.
Gates Iron Works, Chicago, Ill.
McNeal Pipe and Foundry Co., Burlington, N. J.
New York Central Iron Works Co., Geneva, N. Y.
Ohio Pipe Co., Columbus, Ohio.
Robert Poole & Son Co., Baltimore, Md.
R. D. Wood & Co., Philadelphia, Pa.

Cement.

Atlas Cement Co., 143 Liberty St., New York.
New York & Rosendale Cement Co., 280 Broadway, N. Y.

Chain Belting.

Jeffrey Mfg. Co., Columbus, Ohio.
Link Belt Engineering Co., Philadelphia, Pa.

Chemical Works Machinery.

Atlantic Works, East Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Chucks (All Purposes).

Morse Twist Drill & Machine Co., New Bedford, Mass.
Standard Tool Co., Cleveland, Ohio.

Clay Working Machinery.

W. J. Clark & Co., Salem, Ohio.
F. D. Cummer & Son Co., Cleveland, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Clutches, Friction.

Robert Poole & Son Co., Baltimore, Md.

Coal Mining Machinery.

Buffalo Forge Co., Buffalo, N. Y.
W. J. Clark & Co., Salem, Ohio.
W. A. Crook & Bros. Co., Newark, N. J.
General Electric Co., 44 Broad St., New York.
C. W. Hunt, Co., 45 Broadway, N. Y.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, N. Y.
Sullivan Machinery Co., Chicago, Ill.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Coal Washing Machinery.

Cuninghame & Co., Chicago, Ill.

Cold Saws.

Q. & C. Co., Chicago, Ill.

Concentrators and Pulverizers.

Bradley Pulverizer Co., Boston, Mass.
F. D. Cummer & Son Co., Cleveland, Ohio.
Gates Iron Works, Chicago, Ill.

Condensers.

Edw. P. Allis Co., Milwaukee, Wis.
Deane Steam Pump Co., Holyoke, Mass.
Laidlaw-Dunn-Gordon Co., Cincinnati, Ohio.
Southwark Foundry and Machine Co., Phila., Pa.

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Consulting Engineers.

Alton D. Adams, Worcester, Mass.
D. Ashworth, Pittsburg, Pa.
Bryan & Humphrey, St. Louis, Mo.
Blood & Hale, Boston, Mass.
John H. Buckley, Milltown, N. J.
Century Engineering Co., Cleveland, Ohio.
C. M. Conradson, Madison, Wis.
Croze & Dengler, Denver, Colo.
Dr. Willis E. Everette, Tacoma, Wash.
M. Fargusson, Southport, N. C.
Foster & Foyé, 52 Broadway, New York.
C. T. Gooding, Tucson, Ariz.
E. B. Hussey, Seattle, Wash.
E. P. Jennings, Ironwood, Mich.
Julian Kennedy, Pittsburg, Pa.
Oscar Lowinson, 39-41 Cortlandt St., N. Y.
A. L. McRae, St. Louis, Mo.
Pittsburg Testing Lab'y, Ltd., Pittsburg, Pa.
Alexander Potter, New York and Pittsburg.
C. L. Redfield, Chicago, Ill.
H. B. Roelker, 41 Maiden Lane, New York.
Vandenbergh Lab'y of Chem. Ind., Buffalo, N. Y.
Wm. O. Webber, Boston, Mass.

Contractors.

Century Engineering Co., Cleveland, Ohio.
D. Cuozzo, 150 Nassau St., New York.
Julian Kennedy, Pittsburg, Pa.

Contractors' Dump Cars, etc.

Gates Iron Works, Chicago, Ill.

Contractors' Supplies.

John F. Byers Machine Co., Ravenna, Ohio.
Thomas Carlin's Sons, Allegheny, Pa.
H. Channon Company, Chicago, Ill.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
W. A. Crook & Bros. Co., Newark, N. J.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Phila., Pa.
Stearns Manufacturing Co., Erie, Pa.
Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Vulcan Iron Works, Toledo, Ohio.
Watson & Stillman Co., 210 E. 43d St., New York.

Conveying Machinery.

W. J. Clark & Co., Salem, Ohio.
Frick Company, Waynesboro, Pa.
C. W. Hunt Co., 45 Broadway, N. Y.
Jeffrey Mfg. Co., Columbus, O.
John A. Roebling's Sons Co., Trenton, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., N. Y.
Link-Belt Engineering Co., Phila., Pa.

Copper.

Canadian Copper Co., Cleveland, O.
Orford Copper Co., 37 Wall St., New York.

Corrugated Iron.

Berlin Iron Bridge Co., East Berlin, Conn.
Merchant & Co., Inc., Philadelphia, Pa.
Wheeling Corrugating Co., Wheeling, W. Va.

Cranes.

Berlin Iron Bridge Co., East Berlin, Conn.
Manning, Maxwell & Moore, 111 Liberty St., N. Y.
Wm. Sellers & Co., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Crusher Plates.

Chrome Steel Works, Brooklyn, N. Y.
Gates Iron Works, Chicago, Ill.

Crushers, Ore, Phosphate, Rock.

Edw. P. Allis Co., Milwaukee, Wis.
Bradley Pulverizer Co., Boston, Mass.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Chrome Steel Works, Brooklyn, N. Y.

Diamond Drills.

M. C. Bullock Mfg. Co., Chicago, Ill.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Sullivan Machinery Co., Chicago, Ill.
Rand Drill Co., 100 Broadway, N. Y.

Dies and Die Forgings.

E. W. Bliss Co., Brooklyn, N. Y.
Morse Twist Drill & Machine Co., New Bedford, Mass
Toledo Machine and Tool Co., Toledo, Ohio.

Die and Drill Steel.

Chrome Steel Works, Brooklyn, N. Y.
Wm. Jessop & Sons, Limited, 91 John St., N. Y.

Digesters.

Atlantic Works, East Boston, Mass.

Drawing Instruments and Materials.

Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Keuffel & Esser Co., 127 Fulton St., New York.
Queen & Co., Philadelphia, Pa.
E. G. Soltmann, 119 B Fulton St., New York.

Dredging Machines.

W. J. Clark & Co., Salem, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
New York Dredging Co., 61 Park Row, N. Y.
Robert Poole & Son Co., Baltimore, Md.
Vulcan Iron Works, Toledo, Ohio.

Drills, Rock and Coal.

M. C. Bullock Mfg. Co., Chicago, Ill.
General Electric Co., 44 Broad St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Rand Drill Co., 100 Broadway, N. Y.
Sullivan Machinery Co., Chicago, Ill.

Drilling Machines.

W. F. & John Barnes Co., Rockford, Ill.
Baker Brothers, Toledo, Ohio.
Buffalo Forge Co., Buffalo, N. Y.
Davis & Egan Machine Tool Co., Cincinnati, Ohio.
Dietz, Schumacher & Boye, Cincinnati, Ohio
Manning, Maxwell & Moore, 111 Liberty St., N. Y.
Niles Tool Works, Hamilton, Ohio.
Wm. Sellers & Co., Incorp., Philadelphia, Pa.
Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Drop Hammers.

E. W. Bliss Co., Brooklyn, N. Y.
Stiles & Fladd Press Co., Watertown, N. Y.

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Drying and Calcining Machines.

American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
F. D. Cummer & Son Co., Cleveland, Ohio.
Gates Iron Works, Chicago, Ill.

Dynamos.

American Engine Co., Bound Brook, N. J.
H. B. Coho & Co., 203 Broadway, New York.
General Electric Co., 44 Broad St., New York.
Interior Conduit & Insulation Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Thresher Electric Co., Dayton, O.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.

Electrical Machinery and Supplies.

American Engine Co., Bound Brook, N. J.
Bristol Co., Waterbury, Conn.
H. B. Coho & Co., 203 Broadway, New York.
Electric Storage Battery Co., Philadelphia, Pa.
General Electric Co., 44 Broad St., New York.
Interior Conduit & Insulation Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Queen & Co., Inc., Philadelphia, Pa.
Wm. E. Quimby, 59 Liberty St., New York.
Thresher Electric Co., Dayton, O.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Electric Locomotives.

Baldwin Locomotive Works, Philadelphia, Pa.
General Electric Co., 44 Broad St., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
H K. Porter & Co., Pittsburg, Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Elevator Buckets.

W. J. Clark & Co., Salem, Ohio.

Elevator Guards and Screens.

Harrington & King Perforating Co., Chicago, Ill.

Elevators.

Gates Iron Works, Chicago, Ill.
Morse, Williams & Co., Philadelphia, Pa.
Triumph Electric Co., Cincinnati, Ohio.
R. D. Wood & Co., Philadelphia, Pa.

Emery Wheels.

New York Belting & Packing Co., Ltd., New York.
Sterling Emery Wheel Mfg. Co., Tiffin, Ohio.

Emery Wheel Machinery.

Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.

Engineering Instruments.

Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Keuffel & Esser Co., 127 Fulton St., New York.
Queen & Co., Inc., Philadelphia, Pa.
E. G. Soltmann, 119 B Fulton St., New York.

Engines, Blowing.

Edw. P. Allis Co., Milwaukee, Wis.
Southwark Foundry and Machine Co., Phila., Pa.

Engines, Gas, Gasoline, and Petroleum.

Otto Gas Engine Works, Philadelphia, Pa.
Springfield Gas Engine Co., Springfield, Ohio.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Marine.

Atlantic Works, East Boston, Mass.
New York Central Iron Works Co., Geneva, N. Y.

Engines, Stationary.

J. B. Alfree Mfg. Co., Indianapolis, Ind.
American Engine Co., Bound Brook, N. J.
Edw. P. Allis Co., Milwaukee, Wis.
John F. Byers Machine Co., Ravenna, Ohio.
Ball & Wood Co., 120 Liberty St., New York.
Buckeye Engine Co., Salem, Ohio.
Buffalo Forge Co., Buffalo, N. Y.
M. C. Bullock Mfg. Co., Chicago, Ill.
Chandler & Taylor Co., Indianapolis, Ind.
Filer & Stowell Co., Milwaukee, Wis.
Frick Company, Waynesboro, Pa.
Gates Iron Works, Chicago, Ill.
Hooven, Owens & Rentschler Co., Hamilton, Ohio.
New York Central Iron Works Co., Geneva, N. Y.
Southwark Foundry and Machine Co., Phila., Pa.
Stearns Manufacturing Co., Erie, Pa.
Webster, Camp & Lane Machine Co., Akron, Ohio.
Westinghouse Machine Co., Pittsburg, Pa.
Robert Wetherill & Co., Chester, Pa.

Excavators.

Jeffrey Mfg. Co., Columbus, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
New York Dredging Co., 61 Park Row, New York.
Vulcan Iron Works, Toledo, Ohio.

Fans, Ventilating.

Buffalo Forge Co., Buffalo, N. Y.
M. C. Bullock Mfg. Co., Chicago, Ill.

Feed-Water Heaters.

Edw. P. Allis Co., Milwaukee, Wis.
Goubert Mfg. Co., 14 Church St., N. Y.
National Pipe Bending Co., New Haven, Conn.
Robt. Wetherill & Co., Chester, Pa.
Whitlock Coil Pipe Co., Elmwood, Conn.

Fertilizer Machinery.

Bradley Pulverizer Co., Boston, Mass.
Jeffrey Mfg. Co., Columbus, Ohio.
Robert Poole & Son Co., Baltimore, Md

Filters.

Morison-Jewell Filtration Co., 26 Cortland St., N. Y.

Fire Hydrants.

M. J. Drummond, 192 Broadway, New York.
R. D. Wood & Co., Philadelphia, Pa.

Flexible Shafts.

Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Floor and Sidewalk Lights.

T. H. Brooks & Co., Cleveland, Ohio.

Flour Mill Machinery.

Edw. P. Allis Co., Milwaukee, Wis.
W. J. Clark & Co., Salem, Ohio.
Robert Poole & Son Co., Baltimore, Md.

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Fly Wheels.

E lw. P. Allis Co., Milwaukee, Wis.
Robert Poole & Son Co., Baltimore, Md.

Forges.

Buffalo Forge Co., Buffalo, N. Y.

Furnace Builders.

Julian Kennedy, Pittsburg, Pa.

Furniture and Chair Machinery.

J. A. Fay & Co., Cincinnati, Ohio.
The Egan Co., Cincinnati, Ohio.

Gages, Pressure, Steam, Water, etc.

Ashcroft Mfg. Co., 111 Liberty St., New York.
Bristol Co., Waterbury, Conn.

Gas Holders.

R. D. Wood & Co., Philadelphia, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gas Machines and Generators.

American Gas Furnace Co., Elizabeth, N. J.
United Gas Improvement Co., Philadelphia, Pa.

Gas Plants.

American Gas Furnace Co., Elizabeth, N. J.
United Gas Improvement Co., Philadelphia, Pa.

Gas Producers.

R D. Wood & Co., Philadelphia, Pa,
United Gas Improvement Co.. Philadelphia, Pa.

Gas Works Machinery.

Continental Iron Works, Brooklyn, N. Y.
R D. Wood & Co., Philadelphia, Pa.
United Gas Improvement Co , Philadelphia, Pa.

Gaskets, Copper.

U. S. Mineral Wool Co., 2 Cortlandt St., N. Y.

Gate Valves.

Continental Iron Works, Brooklyn, N. Y.
Jenkins Brothers, 71 John St., N. Y.
Lunkenheimer Co., Cincinnati, Ohio.

Gear Cutters.

E. W. Bliss Co., Brooklyn, N. Y.
Brown & Sharpe Mfg. Co., Providence, R. I.
Wm. Sellers & Co., Incorp., Philadelphia, Pa.
Standard Tool Co., Cleveland, Ohio.

Gearing.

Edw. P. Allis Co., Milwaukee, Wis.
Brown & Sharpe Mfg. Co., Providence, R. I.
New Process Rawhide Co., Syracuse, N. Y.
New York Central Iron Works Co., Geneva, N. Y.
Morse, Williams & Co., Philadelphia, Pa.
Robert Poole & Son Co., Baltimore, Md.
Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.

Girders.

Berlin Iron Bridge Co., East Berlin, Conn.
Wrought Iron Bridge Co., Canton, Ohio.

Grain Elevator Machinery.

Edw. P. Allis Co., Milwaukee, Wis.
W. J. Clark & Co., Salem, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link Belt Engineering Co., Phila., Pa.
Robert Poole & Son Co., Baltimore, Md.

Grates.

Vulcan Iron Works, Toledo, Ohio.

Grinding and Polishing Machinery.

Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Cleveland Twist Drill Co., Cleveland, Ohio.
Thomas Carlin's Sons, Allegheny, Pa.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Wm. Sellers & Co., Incorp., Philadelphia, Pa.
Standard Tool Co., Cleveland, Ohio.
Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.

Grips, Cable Railways.

Robt. Wetherill & Co., Chester, Pa.

Guns.

Baker Gun Co., Batavia, N. Y.
Marlin Fire Arms Co., New Haven, Conn.

Hangers.

SEE PULLEYS, ETC.

Heating and Ventilating Apparatus.

American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.

Heaters, Steam and Hot Water.

American Boiler Co., Chicago, Ill.
Gorton & Lidgerwood Co., 96 Liberty St., N. Y.
H. B. Smith Co., 137 Center St., N. Y.
New York Central Iron Works Co., Geneva, N. Y.

Hoisting Engines and Machinery.

Edw. P. Allis Co., Milwaukee, Wis.
M. C. Bullock Mfg. Co., Chicago, Ill.
John F. Byers Machine Co., Ravenna, Ohio.
Thomas Carlin's Sons, Allegheny, Pa.
H. Channon Company, Chicago, Ill.
Contractors' Plant Mfg. Co., Buffalo, N. Y
Cooper, Hewitt & Co., 17 Burling Slip, N. Y.
W. A. Crook & Bros. Co., Newark, N. J.
Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., 45 Broadway, N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Lidgerwood Mfg. Co., 96 Liberty St., N. Y.
Manning, Maxwell & Moore, 111 Liberty St., N. Y.
Wm. Sellers & Co., Incorp., Philadelphia, Pa.
Stearns Manufacturing Co., Erie, Pa.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Webster, Camp & Lane Machine Co., Akron, Ohio

Hollow Bricks.

Henry Maurer & Son, 420 E. 23d St., New York,

Hydrants.

M. J. Drummond, 192 Broadway, New York.
R. D. Wood & Co., Philadelphia, Pa.

Hydraulic Cement.

Atlas Cement Co., 143 Liberty St., New York.
New York & Rosendale Cement Co., 280 Broadway, N. Y.

Hydraulic Machinery.

Watson & Stillman Co., 210 E. 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

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Ice-Making Machinery.

Frick Company, Waynesboro, Pa.
H. B. Roelker, 41 Maiden Lane, New York.
Stillwell-Bierce & Smith-Vaile Co., Dayton, Ohio.

Indicators, Steam-Engine.

Queen & Co., Inc., Philadelphia, Pa.

Injectors.

Detroit Lubricator Co., Detroit, Mich.
Penberthy Injector Co., Detroit, Mich.
Wm. Sellers & Co., Philadelphia, Pa.

Industrial Railways.

C. W. Hunt Co., 45 Broadway, N. Y.

Insulated Wire.

W. R. Brixey, 203 Broadway, N. Y.
The Okonite Co., Ltd., 253 Broadway, N. Y.

Iron.

Passaic Rolling Mill Co., Paterson, N. J.

Joists, Iron and Steel.

Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.
Wrought Iron Bridge Co., Canton, Ohio.

Key-Way Cutter.

Baker Brothers, Toledo, Ohio.

Kiers.

Atlantic Works, East Boston, Mass.

Kyanizing.

Otis Allen & Son, Lowell, Mass.

Lamp Posts.

M. J. Drummond, 192 Broadway, New York.

Lamps, Electric.

General Electric Co., 44 Broad St., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Lathes.

W. F. & John Barnes Co., Rockford, Ill.
E. W. Bliss Co., Brooklyn, N. Y.
Bradford Mill Co., Cincinnati, Ohio.
Dietz, Schumacher & Boyé, Cincinnati, Ohio.
Jones & Lamson Mch. Co., Springfield, Vt.
Davis & Egan Machine Tool Co., Cincinnati, Ohio.
Manning, Maxwell & Moore, 111 Liberty St., N. Y.
Niles Tool Works, Hamilton, Ohio.
Wm. Sellers & Co., Incorp., Philadelphia, Pa.

Locomotives.

Baldwin Locomotive Works, Philadelphia, Pa.
John F. Byers Machine Co., Ravenna, Ohio.
Thomas Carlin's Sons, Allegheny, Pa.
Pittsburg Locomotive Works Pittsburg, Pa.
H. K. Porter & Co., Pittsburg, Pa.
Stearns Manufacturing Co., Erie, Pa.

Locomotive Brakes.

Westinghouse Air Brake Co., Pittsburg, Pa.

Lubricants.

Jos. Dixon Crucible Co., Jersey City, N. J.

Lubricators.

Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, Ohio.

Machine Screws, etc.

Worcester Machine Screw Co., Worcester, Mass.

Machine Tools and Supplies.

Acme Machinery Co., Cleveland, Ohio.
Baker Brothers, Toledo, Ohio.
W. F. & John Barnes Co., Rockford, Ill.
Beaudry & Co., Boston, Mass.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
E. W. Bliss Co., Brooklyn, N. Y.
Bradford Mill Co., Cincinnati, Ohio.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Cleveland Twist Drill Co., Cleveland, Ohio.
Dietz, Schumacher & Boyé, Cincinnati, Ohio.
Hilles & Jones Co., Wilmington, Del.
Jones & Lamson Mch. Co., Springfield, Vt.
Davis & Egan Machine Tool Co., Cincinnati, Ohio.
Manning, Maxwell & Moore, 111 Liberty St., N. Y.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Niles Tool Works, Hamilton, Ohio.
Robert Poole & Son Co., Baltimore, Md.
Q. & C. Co., Chicago, Ill.
Wm. Sellers & Co., Philadelphia, Pa.
Standard Tool Co., Cleveland, Ohio.
Stearns Manufacturing Co., Erie, Pa.
Stiles & Fladd Press Co., Watertown, N. Y.
Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Chas. A. Strelinger & Co., Detroit, Mich.
Toledo Machine and Tool Co., Toledo, Ohio.
Worcester Machine Screw Co., Worcester, Mass.

Marine Machinery.

W. A. Crook & Bros Co., Newark, N. J.

Mathematical Instruments.

Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Keuffel & Esser Co., 127 Fulton St., New York.
Queen & Co., Inc. Philadelphia, Pa.

Merchant Steel.

Wm. Jessop & Sons, Limited. 91 John St., N. Y.

Metals.

Wm. Jessop & Sons, Ltd., 91 John St., N. Y.
Merchant & Co., Inc., Philadelphia, Pa.
Passaic Rolling Mill Co., Paterson, N. J.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.

Metal Lath.

Cincinnati Corrugating Co., Piqua, Ohio.

Metal Punching and Shearing.

Harrington & King Perforating Co., Chicago, Ill.

Meters, Electric.

General Electric Co., 44 Broad St., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Meters, Water.

Union Water Meter Co., Worcester, Mass.

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Milling Machines.

Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Davis & Egan Machine Tool Co., Cincinnati, Ohio.
Wm. Sellers & Co., Incorp., Philadelphia, Pa.

Mine Cars.

Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., 45 Broadway, N. Y.

Mining Machinery.

Bradley Pulverizer Co., Boston, Mass.
M. C. Bullock Mfg. Co., Chicago, Ill.
Chrome Steel Works, Brooklyn, N. Y.
W. J. Clark & Co., Salem, Ohio.
W. A. Crook & Bros. Co., Newark, N. J.
A. S. Cameron Steam Pump Works, E. 23 N. Y.
Gates Iron Works, Chicago, Ill.
General Electric Co., 44 Broad St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffery Mfg. Co., Columbus, Ohio.
Lidgerwood Mfg. Co., 96 Liberty St., N. Y.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, N. Y.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Webster, Camp & Lane Machine Co., Akron, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Mining Screens.

Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.

Motors, Electric.

American Engine Co., Bound Brook, N J.
H. B. Coho & Co., 203 Broadway, New York.
General Electric Co., 44 Broad St., New York.
Interior Conduit & Insulation Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Thresher Electric Co., Dayton, O.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Naphtha Gas Machines.

American Gas Furnace Co., Elizabeth, N. J.

Nickel.

Canadian Copper Co., Cleveland, O.
Orford Copper Co., 37 Wall St., New York.

Oil Cups.

Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, Ohio.
Wm. Powell Co., Cincinnati, Ohio.

Oil Gas Plants.

American Gas Furnace Co., Elizabeth, N. J.

Ore Dressing Machinery.

Cuninghame & Co., Chicago, Ill.

Ore Roasting Machinery.

F. D. Cummer & Son Co., Cleveland, Ohio.
Gates Iron Works, Chicago, Ill.

Ornamental Iron Work.

Winslow Bros. Co., Chicago, Ill.

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Boston Belting Co., Boston, Mass.
Jenkins Brothers, 71 John St., N. Y.
New York Belting & Packing Co., Ltd., New York.

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Detroit Graphite Mfg. Co., Detroit, Mich.
Edward Smith & Co., 45 Broadway, New York.
Joseph Dixon Crucible Co., Jersey City, N. J.

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Robt. Wetherill & Co., Chester, Pa.

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Ohio Pipe Co., Columbus, Ohio.
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National Pipe Bending Co., New Haven, Conn.

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Michigan Pipe Co., Bay City, Mich.

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Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.

Pipe, Spiral Riveted.

Abendroth & Root Mfg. Co., 28 Cliff St., N. Y.

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Hilles & Jones Co., Wilmington, Del.
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Wm. Sellers & Co., Incorp., Philadelphia, Pa.
Stiles & Fladd Press Co., Watertown, N. Y.

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Union Water Meter Co., Worcester, Mass.

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Shultz Belting Co., St. Louis, Mo.

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Robt. Wetherill & Co., Chester, Penn.

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Bradley Pulverizer Co., Boston, Mass.

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Rand Drill Co., 100 Broadway, N. Y.
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Vulcan Iron Works, Toledo, Ohio.

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Passaic Rolling Mill Co., Paterson, N. J.
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Columbia University, New York.
Correspondence School of Technology, Cleveland, Ohio.
International Correspondence Schools, Scranton, Pa.
Lehigh University, South Bethlehem, Pa.

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Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.

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Niles Tool Works, Hamilton, Ohio.

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Separators, Steam.

Culver Manufacturing Co., Scranton, Pa.
Goubert Mfg. Co., 14 Church St., N. Y.

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Stiles & Fladd Press Co., Watertown, N. Y.
Toledo Machine and Tool Co., Toledo, Ohio.

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Gates Iron Works, Chicago, Ill.

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Chrome Steel Works, Brooklyn, N. Y.
Wm. Jessop & Sons, Ltd., 91 John St., N. Y.
Passaic Rolling Mill Co., Paterson, N. J.

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Stokers.

Wm. Sellers & Co., Incorp., Philadelphia, Pa.

Storage Batteries.

Electric Storage Battery Co., Philadelphia, Pa.

Structural Iron Work.

Continental Iron Works, Brooklyn, N. Y.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.
Wrought Iron Bridge Co., Canton, Ohio.

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R. D. Wood & Co., Philadelphia, Pa.

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Queen & Co., Inc , Philadelphia, Pa.

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Continental Iron Works, Brooklyn, N. Y.
New York Central Iron Works Co., Geneva, N. Y.
Pittsburg Locomotive Works, Pittsburg, Pa.

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Vacuum Pumps.

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Clayton Air Compressor Works, 26 Cortlandt St., N. Y.
Deane Steam Pump Co., Holyoke, Mass.

Valves, Gas, Steam, and Water.

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M J. Drummond, 192 Broadway, New York.
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Stow Flexible Shaft Co., Ltd., Philadelphia, Pa.

Worm Gears.

Morse, Williams & Co., Philadelphia, Pa.

Wrecking Cars.

Marion Steam Shovel Co., Marion, Ohio.

Yachts, Steam.

Atlantic Works, East Boston, Mass.

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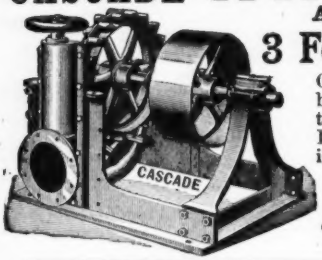

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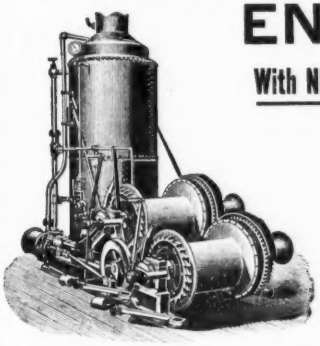

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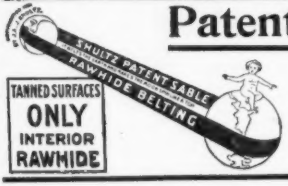

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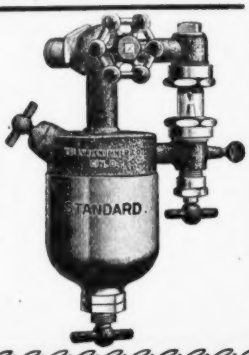

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